JOURNAL OF THE A·I·E·E·

FEBRUARY 1924

PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

MIDWINTER CONVENTION NUMBER

Come to the

MIDWINTER CONVENTION
in Philadelphia

February 4 to 8

ENGINEERING AND SCIENTIFIC PAPERS

Original Studies and New Treatments

SPECIAL FEATURES

40th Anniversary Celebration

Transportation Meetings

Edison Medal Presentation

Moore School Dedication

TRIPS

PENNSYLVANIA R. R.
Locomotive Exhibit
and Shops

BETHLEHEM
Bethlehem Steel Co.
Lehigh University

HISTORICAL SITES
Dating from Franklin's
Day

ENTERTAINMENT

LADIES
Special Arrangements
made

DINNER DANCE
The outstanding
annual social function

SOIREE-POT-POURRI
An evening of
relaxation

(For further information see page 160 of this issue)

JOURNAL

OF THE

American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street, New York

Subscription. $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines; $10.50 to Canada and $11.00 to all other Countries. Single copies $1.00.

Entered as matter of the second class at the Post Office, New York, N. Y., May 10, 1905, under the Act of Congress, March 3, 1879. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.
Printed in U. S. A.

Vol. XLIII FEBRUARY, 1924 Number 2

TABLE OF CONTENTS

Papers, Discussions, Reports, Etc.

Institute and Related Activities

Coming Meetings

Spring Convention, Birmingham, Alabama, April 7-10.

Annual Convention, Edgewater Beach, Chicago, Ill.

Pacific Coast Convention, Pasadena, Cal., October

Current Electrical Articles Published by Other Societies

Transactions of the Illuminating Engineering Society, December

Eleven Solutions of a Street Lighting Problem.

Pageant Street Lighting, by Samuel G. Hibben.

Association of Iron & Steel Electrical Engineers, December

Installation and Operation of Static Condensers, by P. T. Vanderwaart.

Journal of the A. I. E. E.

Devoted to the advancement of the theory and practise of electrical engineering and the allied arts and sciences

Vol. XLIV FEBRUARY, 1924 Number 2

What Others Say of Us

FORTY years ago a small group of enthusiastic electrical engineers, imbued with foresight and courage and full of professional pride, formed the American Institute of Electrical Engineers. A few days hence—on Monday evening, February 4—in the City of Brotherly Love hallowed by Benjamin Franklin and other revered founders of the nation, the Institute will celebrate its fortieth birthday. These pioneers of 1884 created wisely and built well—in fact, better than they then could realize. Happily, many of them are still living to marvel at the great professional organization which stands as a monument to their work and which wields a worldwide influence for good. It has kept unsullied the splendid ideals of that early day, which were implied in the objects so felicitously enunciated—"The advancement of the theory and practise of electrical engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members, and the development of the individual engineer."

The influence of the Institute may well be measured in terms of men who have guided its destinies and contributed so greatly to the development of the art. Elihu Thomson, Edward Weston, Alexander Graham Bell, Frank Julian Sprague, Francis Bacon Crocker, John J. Carty, Charles P. Steinmetz, Henry G. Stott and Schuyler Skaats Wheeler, past-presidents of the Institute, will always be recorded among the men whose names signify engineering accomplishments of remarkable brilliancy. On the list of members living and dead are, besides, such honorable names as George Westinghouse, William Stanley, Charles F. Brush, Nikola Tesla, Benjamin G. Lamme, Elmer Sperry, Michael I. Pupin and Robert A. Millikan, not to allude to the thousands of others whose co-ordinated efforts have made possible the present astounding achievements in the electrical industry.

The laurels of the Institute have been earned by its members, who have faithfully and brilliantly carried the light of electrical science into new realms. History cannot parallel the growth and accomplishments of the art of electrical engineering, and every member of the profession is proud and delighted to pay homage to the Institute as the technical body with which this wonderful and gratifying record is most closely entwined. The Institute symbolizes the profession and its ideals and receives the loyalty and devotion of all.

The entire electrical industry unites with the members of the Institute in this celebration of its fortieth birthday and wishes it even greater honor and success in its future efforts to bring a still more comprehensive realization of the objectives so well visioned and stated by the pioneers.—*Electrical World.*

Natural Science and Political Science

IT is a far cry from the laws of Newton, Faraday and Maxwell to the League of Nations, world unrest, and international politics, and it is interesting to note that Dr. M. I. Pupin will attempt to make an analogy between the underlying laws of heat, electricity and gravity, and the laws underlying the forces of society and of economics. Yet the more special analogy between the uncoordinated energy of heat in a gas resulting in the indiscriminate mutual bombardment of molecules and the present social and political activities of mankind is very pretty and appealing to the mind of scientific training.

As a result of the scientific study of heat the scientists has been able to coordinate this energy, state the laws underlying it in exact terms and show how this uncoordinated energy may be coordinated and put to a useful beneficent purpose in the steam engine. From this the step is not so great to the thesis that if someone could state the laws underlying the uncoordinated forces of mankind and show how they could be coordinated and united to some useful and common end, it would produce a social mechanism even more valuable and beneficient than the steam engine.

Dr. Pupin is well known as a scientist who has a keen understanding of human nature, and his theories along this line, which he will disclose in an address announced elsewhere in this issue, will be awaited with much interest.

Electrical Museums

ONE subject ever a topic of discussion when electrical engineers gather at conventions is that of adequate and proper permanent housing for existing historical electric machines and devices.

Years ago, before the office needs of the Institute necessitated assigning all available space to desks and

routine service, the Institute's rooms in the Engineering Societies Building, New York, were regarded as a logical place to store and display electrical relics. Some valuable collections were sent in and were placed on exhibition, notably the Hammer Collection of incandescent lamps.

The gradual lessening of the space available for this purpose in the Engineering Societies Building simultaneously with the growing interest in historical collections presents a situation well worth consideration at this time.

The Smithsonian Institution at Washington has a very valuable and interesting collection of early telegraph, telephone and electric power equipment. A day spent in the Smithsonian Institution studying the elements of these machines is the equivalent of many days search through the pages of historical publications for the purpose of gaining information bearing on the genesis of the electric industries.

Several of the Universities and a number of the large Manufacturing Companies maintain Museums, but the relics deposited in these places are seen only by a relatively small number of the many engineers and students who are interested in historical development and in the perspective of progress.

There is in the situation an opportunity for an engineer or a group of engineers in control of the requisite means to set in motion plans for the establishment of a centrally located, single museum to which might be forwarded for housing and display the bulk of the historical apparatus now stored in basements and lofts as well as specimens of present day devices which in time will become obsolete and historical.

Space in the JOURNAL will be given to letters on this subject addressed to the editor.

Writing and Speaking for Engineers

At intervals more or less frequent situations are presented in the daily press which point to the desirability of engineers interesting themselves in public affairs. Editorial writers on occasion sound a cry for the service of engineers in National, State and local affairs, the inspiration springing from the need of eliminating waste and of insuring economy in the expenditure of the public's money.

If, on an appreciable scale, engineers are to become directly identified with public affairs it is probable that in order that they may play a part at the source—the point of inception—their entry may be made to the best advantage through the same avenues as those followed by members of the legal profession—speaking and writing.

Speaking and writing for engineers, as elements of training, are now given more attention than was the case years ago. It is noteworthy that papers presented at Institute meetings by the younger engineers are delivered in a more successful manner than papers presented by older engineers who have had little training and little experience in public speaking.

Often at conventions there is opportunity to observe the respective abilities of engineers to present technical papers clearly and convincingly to large audiences. Occasionally large auditoriums are filled to capacity with engineers who sit through long sessions listening to a fellow member reading, haltingly, a long paper which would be difficult enough to understand in its entirety if presented in good voice and with clear enunciation.

An efficiency expert might remind us that when 1200 engineers devote an evening to listening to the presentation of a technical paper there is a total of perhaps 3600 engineer-hours invested, plus auditorium charges, personal transportation charges and cost of preparing the paper. The total expenditure is formidable—enough surely to suggest that the actual presentation of the paper should measure up to some sensible standard.

A good paper is largely added to in value by being well presented. To justify taking up the time and attention of a large body of engineers it would seem that authors who intend personally to present their papers should resort to the benefits of rehearsal and of coaching. Time contributed to this and by one man—the author—conserves the time of hundreds of engineers who attend meetings. Also, the reception accorded a paper always is more enthusiastic and appreciative when it is presented in a manner in keeping with the setting of the occasion.

Practise in writing and speaking on purely technical subjects is training of the sort that should qualify engineers to talk convincingly and pleasingly on subjects of general public interest and engineers who are successful in replacing the genus politician in public affairs must of necessity be good speakers.

Suggestions to Authors

The Meetings and Papers Committee of the Institute has undertaken to prepare some suggestions to authors with a view to laying down certain rules and specifications to be followed by authors in the preparation of manuscripts of Institute papers. The great increase in volume of Institute publications make specific rules necessary for the conservation of both money and time required in publishing papers.

While some time may be required to complete the new rules, the following suggestion can be made at once, and its observance will save the Institute hundreds of dollars each month: Do not send blue prints for illustrations. Trace in black ink only what is necessary for the illustration, and letter the tracing with a lead pencil so that it can be erased and stamped with proper size letters and figures to suit the reduction in size. Do not use cross-section paper with lines closer than half an inch.

Automatic Transmission of Power Readings

BY B. H. SMITH
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

and

R. T. PIERCE
Associate A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

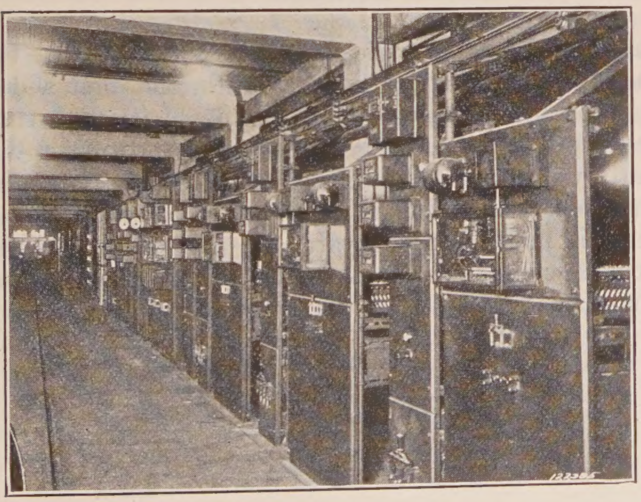
Review of the Subject.—*The need of information at one point as to power conditions in large systems for load dispatching, billing, or other purposes has led to the development of various methods of transmitting power readings over long distances. The development of superpower emphasizes this need and the perfection of means of communicating complete information as to power and load conditions will hasten the development of superpower.*

We wish to discuss various automatic methods which may be employed for remote metering. Our paper will describe the following methods:

1. *Frequency*
2. *Inverse Current*
3. *Potentiometer*
4. *Position*
5. *Voltage*
6. *Current*
7. *Impulse*

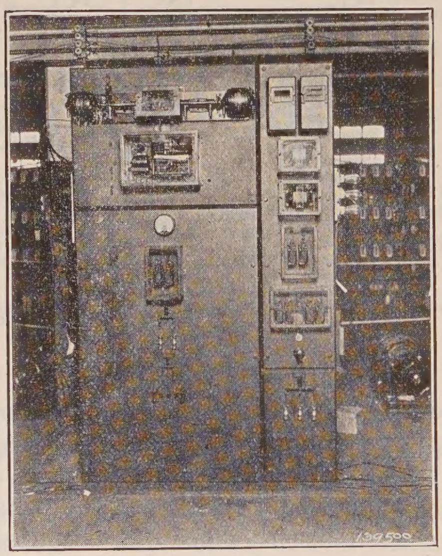
Frequency Method

ONE of the earliest developments in the field of long distance metering has now been in operation on the Pacific Coast Electrified Section of the C. M. & St. P. R. R. for several years. Its purpose there is to register the total amount of power received at several substations from a hydroelectric company, to indicate and record this total at the dispatcher's office and then to send back controlling impulses over the line which regulate the trolley voltage and maintain as steady an electrical load as possible and prevent the occurrence of heavy peaks. A pair of No. 8 copper wires was installed over the whole length of the electrified section especially for the metering system, and over this line is transmitted at from 1000 to 2000 volts alternating current whose frequency varies anywhere from 20 to 60 cycles depending upon the load measured. If the load is heavy the wattmeters through suitable



Test Set Up—C. M. & St. P. R. R., Frequency Method

speed regulating apparatus increase the speed of small a-c. generators until just the right frequency is sent out equivalent to the measured power. At each station the frequency of the metering circuit is regulated so as to be equivalent to the total power from all stations up to that point, and then at the dispatcher's office the frequency is translated back to watts in a local 60-cycle circuit. This is accomplished as follows: The incoming frequency operates a small synchronous motor whose speed is measured by a speedometer which in turn is balanced against a Kelvin balance wattmeter until the watts are made equivalent to the incoming frequency and thus the total power consumed by the railroad. The local circuit then leads to record-



Apparatus of Intermediate Station—Frequency Method

ing meters, watthour, recording demand, plain indicating wattmeters and a regulator. Thus the dispatcher has immediately available a complete and up-to-the-minute record of the power conditions of the road. This system has given exceptionally good service, but there are several factors involved which preclude universal adoption. First the amount of power required to actuate the metering apparatus and which must be transmitted over the lines is about 40 watts. This amount of power cannot be transmitted over existing telephone or signal lines and involves a special line costing several hundred dollars per mile for copper alone. In addition the sending and receiving apparatus is not suitable for installation on the premises of the average power consumer due to size, energy consumption, and attention required.

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924.

Inverse Current Method

Another early installation was on the Montana division of the C. M. & St. P. R. R. Here a current, inversely proportional to the load, is transmitted over a special metering circuit. The wattmeters in each substation measure the a-c. power and regulate an automatic rheostat until resistance is introduced in the metering circuit proportional to the load. All stations are connected in series and a constant voltage is maintained in the dispatcher's office at one end of the circuit. The total resistance in all the stations and the line resistance reduces the current in the circuit to a minimum for full scale readings of the meters in the dispatcher's office, of about 250 milliamperes. As the load decreases this current increases and the fluctuations are recorded in the dispatchers office on graphic milliammeters and various regulating instruments.

The receiver consists of a contact-making galvanometer which operates a slider across a resistance. A voltage is applied to this resistance which opposes the voltage applied to the transmitter slide. Consequently the slider on the receiver takes up a position where the receiver voltage is equal to the transmitter voltage and no current flows. If both resistances are in equal steps, the position of the receiver slide is the same as the position of the transmitter slide.

This method is very accurate as long as equal currents are maintained in the local slider circuit. It is a "Nul" method so that it is independent of transmission line resistance, the only effect of a high-resistance line being a lower accuracy in the receiving instrument.

The main objection to this method is the complicated connections required to give indications and totalization. A second slide and slider is placed on the receiver operating in parallel with the first slider. A constant voltage is applied to this second slide resistance. It requires a voltage regulator to keep this battery voltage constant. This voltage from one end of the slide to the slider is applied to a voltmeter whose scale is marked in kilowatts for indicating purposes and these voltages, as taken from several receivers, are connected in series for totalizing purposes.

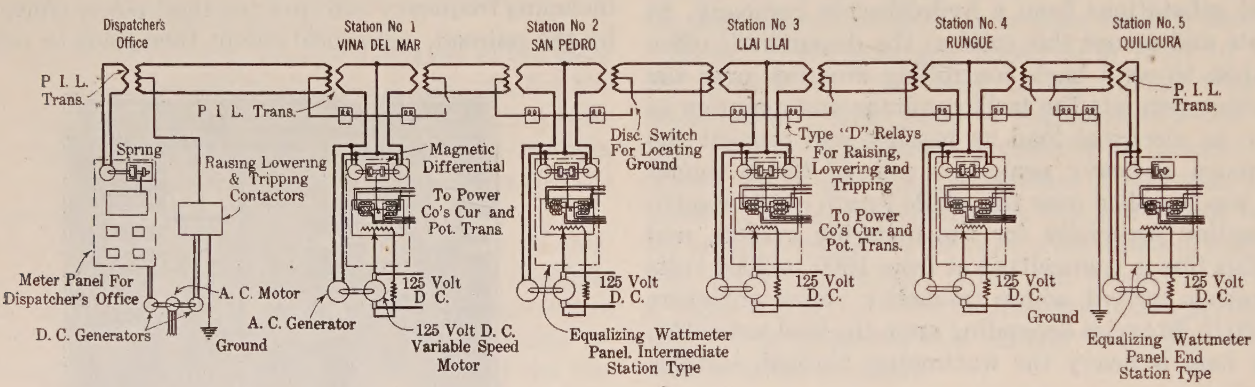
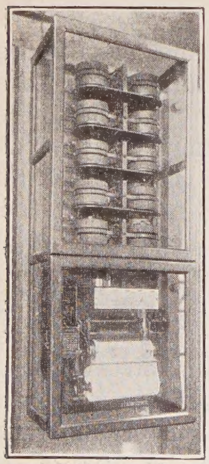


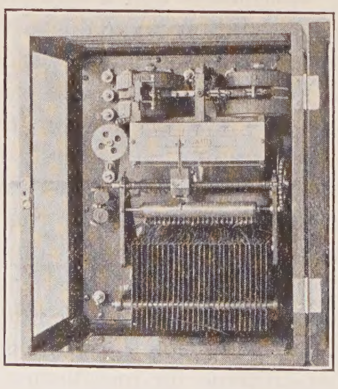
Fig. 1—Schematic Diagram of Indicating and Limiting Equipment

Potentiometer Method

A standard relay-type graphic wattmeter, either single-circuit or totalizing, is equipped with a slide resistance and a slider is fastened on the pen carriage. A voltage is applied to the slide and the voltage drop from one end of slide to slider is transmitted to the receiver.



Totalizing Transmitter—Potentiometer Method



Receiver—Potentiometer Method

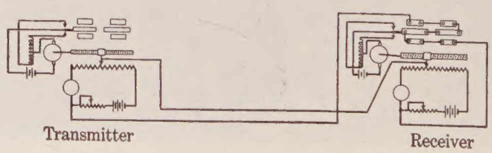


Fig. 2

This is the method employed at the Springdale station of the West Penn Power Co. Totalizing graphics are used for measuring purposes and there are several single-circuit receiving instruments in various parts of the power station. By gearing a long pointer on the worm which operates the receiving slider, a large diameter boiler room indicator is obtained. Alternating-current control is used on this installation.

Fig. 2 shows schematic diagram of this method.

Position Method

Fundamentally this method consists of the use of one of the various types of position transmitters, so connected as to take up positions corresponding to the power measured, and a proper receiver at the receiving end. The Kelvin balance relay type graphic meter may be used to measure the power and the position transmitter properly geared to the mechanism which drives the pen across the paper.

There are various types of position transmitters which would apply here but we believe the induction

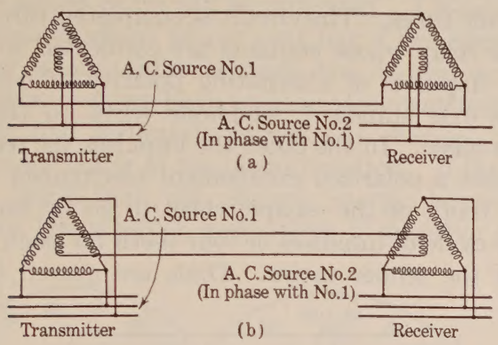


Fig. 3
a—Single-phase excitation.
b—Three-phase excitation.

type has a wider application than most and will, therefore, discuss it in more detail.

If two induction motors are connected as shown in Fig. 3 any motion produced in one will be closely followed by the other. A vane type of synchronoscope may be substituted for the receiving motor and its pointer will follow the rotation of the transmitter rotor. Thus the dial may be marked in kilowatts if the transmitter is connected mechanically to the pen mechanism of the above mentioned graphic.

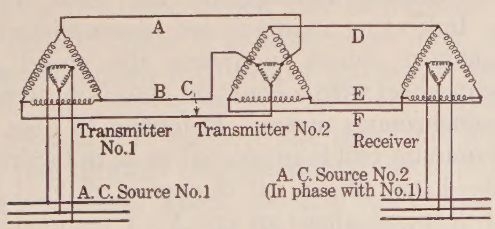


Fig. 4

For totalization, a totalizing graphic could be used for making the measurements and the transmitter connected to it. Another method of totalizing would be to connect the transmitters on several single-circuit graphics in concatenation so that the positions are additive. This requires the use of a three-phase supply as shown in Fig. 4.

If Transmitter No. 1 rotates, this causes a phase rotation in the rotor windings of Transmitter No. 2 which acts as a transformer so that the receiver is rotated through a corresponding angle. Now if Transmitter No. 2 is rotated this adds an angular displacement in wires *D—E—F*, so that its motion is added on to that of Transmitter No. 1 and the receiver shows the sum of the two.

Voltage Method

This method consists of mounting a slider on the pen carriage of a relay-type graphic wattmeter which will operate over a slide wire to which constant voltage is applied. The drop across the slide is transmitted to a voltmeter calibrated to read kilowatts. If it is desired to totalize several of these the voltages are connected in series so that the receiving voltmeter reads the sum. See Fig. 5.

Adjusting rheostats and a small ammeter are shown in the slide circuit so that adjustments may be made to take care of changes in battery voltage.

Current Method

This method is similar to the potentiometer method but is much simpler. The power to be transmitted is measured by a Kelvin-balance-wattmeter element with the control spring omitted. A d'Arsonval meter element has its moving element mechanically con-

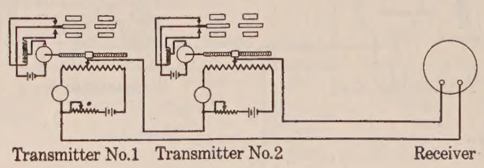


Fig. 5

nected to the moving element on the Kelvin balance. The contacts on the Kelvin balance control a motor-operated rheostat which varies the current in the d'Arsonval meter element until its torque is equal and in opposition to the torque of the Kelvin balance. This current is therefore proportional to the power being measured.

A standard direct-current ammeter serves as a receiving instrument and may be indicating or graphic. Several instruments may be connected in series both in the generating station and at the remote point without changing the calibration of those already installed or destroying the accuracy of each individual receiving instrument. This is done in some cases to widely distribute the readings.

If it is desired to totalize the power from several generating stations, the direct-current control circuits from the various transmitters are connected in parallel so that the receiving instrument measures the sum of all currents.

Fig. 6 shows a simple transmitter and receiver outfit. The contact making Kelvin balance operates the motor which, in turn, operates the slide arm. Since the torque of the Kelvin balance increases in equal steps for equal increases in power, the counter

torque produced by the d'Arsonval meter element must increase in uniform steps. Since the scale of a d'Arsonval meter is uniform the curve of transmitted current against power measured will be a straight line passing through zero.

It should also be noted that since the operation of the apparatus depends on current, it is independent of control voltage.

Fig. 7 shows connections for totalizing several transmitters.

In some cases it is desirable to obtain watthour meter readings at the receiving end. This is accomplished by

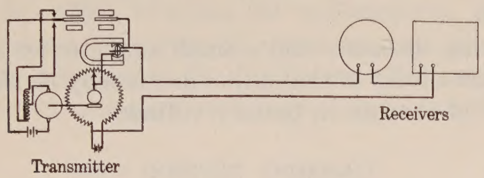


Fig. 6

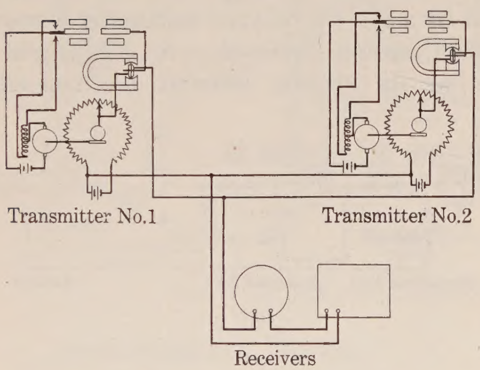


Fig. 7

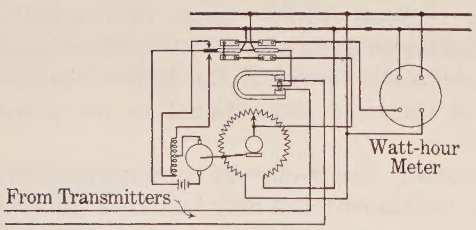


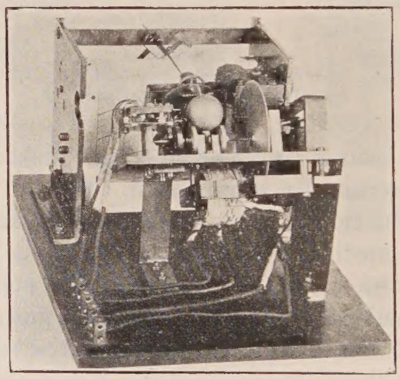
Fig. 8

using a transmitter at the receiving end connected in reversed. The direct current is brought into the d'Arsonval meter element and the rheostat controls the alternating current from an auxiliary source which passes through the Kelvin balance and watthour meter in series. Fig. 8 shows this connection.

This method allows the transmitting of readings over telephone lines without interfering with conversation up to distances of twenty-five miles.

Direct-current Impulse Method

Another solution of long distance metering problems is found in the method of transmitting indications by means of a series of d-c. impulses the frequency of which is proportional to the sending meter speed. A system of this kind has now been operating for some months on a street railway system in connection with supervisory Control of automatic substations from a central load dispatcher's office. Power is measured on polyphase watthour meters in each substation. These meters are equipped with commutators on the main shaft, and with brushes and brush rigging similar to that on a d-c. watthour meter. Alternate opposite pairs of segments are short-circuited so that for every revolution of the shaft a circuit is alternately made and broken four times. The circuit is completed through a telephone relay whose contacts are connected so as to transmit impulses of alternating polarity of not over 100 volts over standard telephone wires to the dispatcher's office. In the office the impulses are received and actuate a polarized excapement mechanism which allows a tooth of the escape wheel to go by for each complete cycle of impulses or four teeth for each revolution of the sender meter. Dials are geared to the

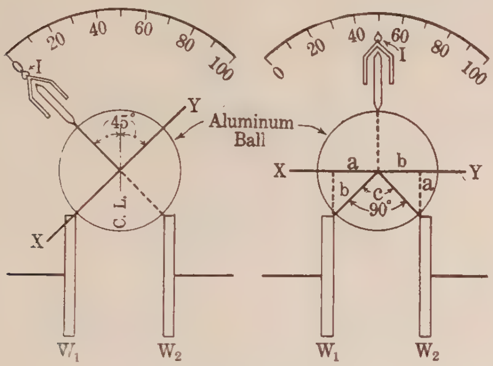


Graphic Receiver—Impulse Method (Rear View)

escapement wheels and register the total watthour reading. Indicating readings are accomplished by a ball mechanism which compares the speed of the escapement wheel with a constant speed obtained from a small synchronous motor. Referring to Figs. 9 and 10, an aluminum ball is supported so as to be driven by wheels $W-1$ and $W-2$. If the speed of $W-1$ is zero, the ball will rotate about an axis $X-Y$ inclined 45 deg. from the horizontal. If the two wheels have equal speeds the axis will be horizontal and at any point between these limits the position of the axis is an indication of the ratio of speeds of $W-1$ and $W-2$. In order to determine the characteristics of this relation; it is necessary to consider the triangle $a-b-c$, and $a-1$, $b-1$ and $c-1$; a and b being radii drawn from the point of contact fo the wheels $W-1$ and $W-2$, to the axis of rotation and, therefore, proportional respectively to the speeds of the two wheels. Since the angle between c and $c-1$ has been fixed at 90 deg. the two triangles are similar and equal and the sides, a, b, and c are equal to $a-1$, $b-1$ and $c-1$ and c/a is

tangent of the angle which measures the departure of the axis from the zero position. Therefore the receiver meter, the position of whose indicating pointer is determined by this axis has its scale divisions marked proportional to the tangents of angles from 0 to 45 deg. over which range the scale is near enough uniform for practical use.

The time required for the pen or pointer to travel from one point to another with change of load is about 8 seconds, but as with other meters the time has a logarithmic characteristic and tests show that with a peak load lasting five seconds approximately 90 deg. of the actual value will be indicated. A 3-second peak will register about 60 per cent but if the current holds up for about eight seconds the indication will be complete, thus we have an indicating wattmeter which quickly and accurately responds to change in speed of the sender meter at the distant station. If the distance is so great that not enough energy is received to actuate the receiver mechanism a sensitive telegraph relay is interposed which will operate on one or two milliamperes. Where the above system is operated over telephone lines, speech may be transmitted at the same time. There is a faint noise from the meter impulses although with proper precaution this can be reduced so that it is not seriously objectionable. It is necessary to connect the telephone instruments to the line through condensers and use high-frequency calling apparatus which will also operate through the condensers as shown in the diagram, Fig. 11. This procedure is necessary, otherwise the meter impulses would be short-circuited by the telephone instruments. In order to prevent the telephone current from entering the metering apparatus, choke coils are interposed ahead of the latter which allow the low-frequency impulses to pass but keep out the relatively high voice frequencies.



Figs. 9 and 10—Remote Metering "Receiver" Analysis of Ball Mechanism

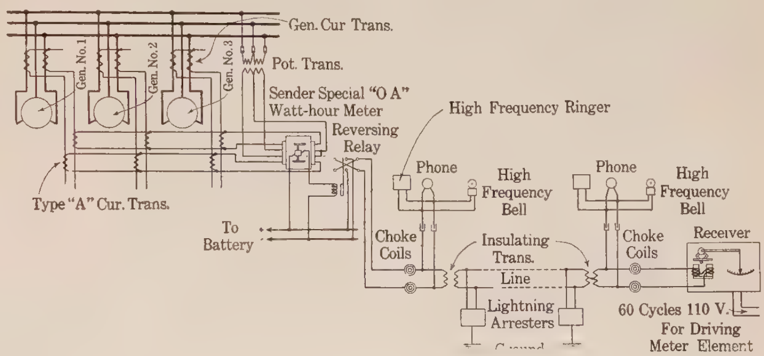
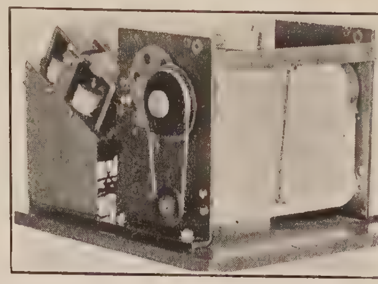


Fig. 11—Impulse Method. Schematic Diagram

As in the telegraph industry the need arises for transmitting several messages or indications at once over one pair of wires. This is accomplished by duplexing when one indication is required each way, or by quadruplexing where two indications are required each way. The principle involved with metering as in telegraphy involves polarized relays which respond to reversal of direction of current and marginal relays to



Graphic Receiver—Impulse Method (Front View)

increased quantity of current. The home relays do not respond to outgoing messages because the current divides in a differential winding between the line circuit and an artificial local circuit. In this class of service difficulty is encountered on outside lines, but with underground cables good results are obtained.

Large Boiler Room Indicator

In general this method compares well in results obtained and in distances transmitted with the telegraph industry.

Some Theoretical Considerations of Power Transmission

BY C. L. FORTESCUE and C. F. WAGNER
Fellow, A. I. E. E. Associate, A. I. E. E.
Both of Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Review of the Subject.—*The following points are developed in the paper:*

1. A proof of the circle diagram maintaining therein the idea of the angle between the generator and receiver voltages.

2. It is shown how the characteristics of the synchronous condenser limit the maximum power that can be transmitted over a line.

3. The effect of character of load on stability.

4. Comparison of 500-mile straightaway line with 500-mile line with condenser at mid-point.

THE power circle diagram of transmission line performance has proved of great value to the line designer and to the analyst. This diagram was first presented by R. A. Philip[1] before the Institute. The circle gives the relation between real and reactive powers, which must be maintained at the receiver to obtain the assumed voltage conditions at the generator and receiver. Mr. R. A. Philip restricted its application to short lines in which the capacity could be neglected, while H. B. Dwight[2] extended its use to the general case of any line. Later H. B. Dwight[3] in a paper presented before the Institute and R. D. Evans and H. K. Sels[4] in a series of articles in the *Electric Journal* developed the diagram still further and indicated simple means whereby the impedances of the transformers may be included. The latter also developed simplified formulas for the calculation and plotting of losses and efficiencies. It is the purpose of the present paper to develop further the uses and properties of the circle diagram.

Let us consider for the present the diagram for the line itself. Let

r = Resistance of line in ohms per mile
x = Reactance of line in ohms per mile
g = Conductance of line in mhos per mile (very small and usually neglected)
b = Susceptance of line in mhos per mile
l = Length of line in miles

then $Z = l\,(r + j\,x)$
$Y = l\,(g + j\,b)$

The familiar steady state line equations may be written

$$\begin{aligned} \check{E}_s &= A\,\check{E}_r + B\,\check{I}_r \\ \check{I}_s &= A\,\check{I}_r + C\,\check{E}_r \end{aligned} \qquad (1)$$

Where $\check{E}_s$ = Voltage (phase-to-neutral) at generator end
$\check{I}_s$ = Current per line at generator
$\check{E}_r$ = Voltage (phase-to-neutral) at receiving end
$\check{I}_r$ = Current per line at receiving end

$$A = \cosh\sqrt{Z\,Y} = 1 + \frac{Y\,Z}{2} + \frac{(Y\,Z)^2}{24} + \frac{(Y\,Z)^3}{720} + \dots$$

$$B = \sqrt{Z/Y}\,\sinh\sqrt{Z\,Y} = Z\left[1 + \frac{Y\,Z}{6} + \frac{(Y\,Z)^2}{120} + \frac{(Y\,Z)^3}{5040} + \dots\right]$$

$$C = \sqrt{Y/Z}\,\sinh\sqrt{Z\,Y} = Y\left[1 + \frac{Y\,Z}{6} + \frac{(Y\,Z)^2}{120} + \frac{(Y\,Z)^3}{5040} + \dots\right]$$

Mr. R. D. Evans and Mr. H. K. Sels in a companion paper show how the transformer constants may be included in the above constants.

Equations (**1**) may be written in the form:

$$\left.\begin{aligned} \check{I}_s &= (\alpha + j\,\beta)\,\check{E}_s - (\gamma + j\,\delta)\,\check{E}_r \\ \check{I}_r &= (\gamma + j\,\delta)\,\check{E}_s - (\alpha + j\,\beta)\,\check{E}_r \end{aligned}\right\} \qquad (2)$$

where

$$\left.\begin{aligned} (\alpha + j\,\beta) &= A/B \\ (\gamma + j\,\delta) &= 1/B \end{aligned}\right\} \qquad (3)$$

Proof of the Circle Diagram[5]

From this point a proof of the circle diagram is readily derived. The conjugate equations of (**2**) may be written:

$$\begin{aligned} \hat{I}_s &= (\alpha - j\,\beta)\,\hat{E}_s - (\gamma - j\,\delta)\,\hat{E}_r \\ \hat{I}_r &= (\gamma - j\,\delta)\,\hat{E}_s - (\alpha - j\,\beta)\,\hat{E}_r \end{aligned}$$

Multiplying $\hat{I}_s$ by $\check{E}_s$ and $\hat{I}_r$ by $\check{E}_r$ we obtain the power at generator and receiver respectively.

$$\begin{aligned} P_s + j\,Q_s &= \check{E}_s\,\hat{I}_s = (\alpha - j\,\beta)\,\check{E}_s\,\hat{E}_s - (\gamma - j\,\delta)\,\hat{E}_r\,\check{E}_s \\ P_r + j\,Q_r &= \check{E}_r\,\hat{I}_r = (\gamma - j\,\delta)\,\hat{E}_s\,\check{E}_r - (\alpha - j\,\beta)\,\hat{E}_r\,\check{E}_r \end{aligned}$$

but $\check{E}_s\,\hat{E}_s = E_s^2$ and $\check{E}_r\,\hat{E}_r = E_r^2$.

If we let $\check{E}_r$ be the datum line and $\check{E}_s = E_s\,\epsilon^{j\,\theta}$ then

---

1. Transactions A. I. E. E., Vol. 30, 1911, pp. 596-636.
2. *Electric Journal*, August 1914, Vol. XI, p. 487.
3. Transactions A. I. E. E., Vol. 41, 1922, pp. 781-784.
4. *Electric Journal*, July, Aug. and Dec. 1921 and Feb. 1922.

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924.

5. An alternate simpler proof not involving conjugate imaginary quantities is given in the companion paper by Evans and Sels. The idea of the angular displacement between generator and receiver voltages, however, is lost.

$\hat{E}_r \check{E}_s = E_r E_s \epsilon^{j\theta}$ and $\check{E}_r \hat{E}_s = E_r E_s \epsilon^{-j\theta}$. Substituting in above

$$P_s + j\,Q_s = (\alpha - j\,\beta)\,E_s^2 - (\gamma - j\,\delta)\,E_s E_r\,\epsilon^{j\theta} \qquad (4)$$

$$P_r + j\,Q_r = (\gamma - j\,\delta)\,E_s E_r\,\epsilon^{-j\theta} - (\alpha - j\,\beta)\,E_r^2 \qquad (5)$$

With E_s and E_r constant, equation (4) is the equation of a circle with its center at $(\alpha - j\,\beta)\,E_s^2$ and radius equal to $\sqrt{\gamma^2 + \delta^2}\,E_s E_r$. For different values of E_r with E_s constant the equation may be represented by a family of concentric circles. These are the so-called "supply circles."

For $\theta = 0$

$$P_s + j\,Q_s = (\alpha - j\,\beta)\,E_s^2 - (\gamma - j\,\delta)\,E_s E_r$$

Operating by $\epsilon^{j\theta}$ merely rotates the vector $-(\gamma - j\,\delta)\,E_s E_r$ through an angle θ in a positive (counter-clockwise) direction. Similarly $P_r + j\,Q_r$ may be

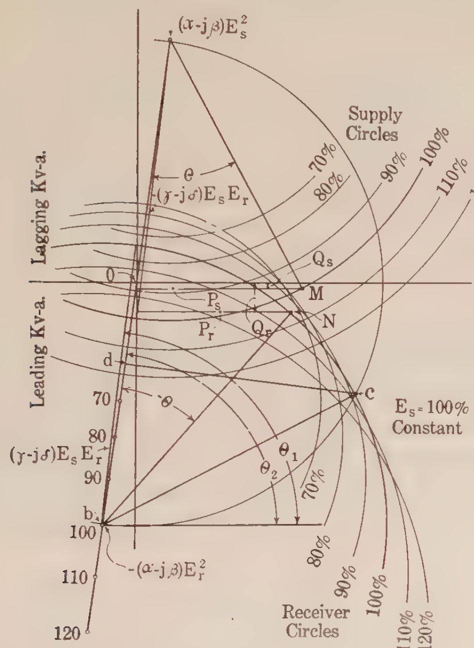


FIG. 1

Showing family of supply and receiver circles, relation between $P_r + j\,Q_r$ $P_s + j\,Q_r$ for any angle θ between E_s and E_r, and graphical determination of envelope.

represented by a circle locus, the center of which is given by $-(\alpha - j\,\beta)\,E_r^2$ which changes with each value of E_r and whose radius is $\sqrt{\gamma^2 + \delta^2}\,E_s E_r$. The vector $(\gamma - j\,\delta)\,E_s E_r\,\epsilon^{-j\theta}$ makes the angle $-\theta$ with $(\gamma - j\,\delta)\,E_s E_r$ as datum. For different values of E_r the equation may be represented by a family of non-concentric circles. These are the so-called "receiver circles."

Fig. 1 shows such a family of "supply" and "receiver" circles. These circles indicate the relation between inductive and real power which must be maintained to obtain the voltage conditions assumed for each circle, *viz.*, E_s constant and giving E_r the values indicated in each circle. It will be noted in this proof that the idea of the angle between the generator and receiver voltages has not been lost. Therefore, for any given value of $P_r + j\,Q_r$ the value of $P_s + j\,Q_s$ at the sending end may be obtained by using the same scalar values of voltage and laying off the same angles from their respective datum lines. For example suppose we are operating at the point N on the 100 per cent receiver circle. By laying off the same angle θ on the 100 per cent supply circle as that corresponding to $-\theta$ on the receiver circle the point M is obtained. This gives the value of true and reactive power at the generator end necessary to maintain the given conditions at the receiver end. $P_s - P_r$ represents the true line loss. This method does not offer very great accuracy, but for most work should be close enough.

The circle diagram could be made more complete by plotting thereon loci of constant angle between generator and receiver circles. It can be shown that these loci are parabolas. However, the angle loci are relatively unimportant and of academic interest only.

GRAPHICAL DETERMINATION OF ENVELOPE

In the analysis of transmission line problems, it is sometimes convenient to know the envelope of the receiver circles. One of its applications is developed in the companion paper by Evans and Sels. Equation (5) may be rewritten as follows:

$$(P_r + \alpha\,E_r^2 + j\,(Q_r - \beta\,E_r^2) = (\gamma - j\,\delta)\,E_s\,E_r \epsilon^{-j\theta} \quad (6)$$

Its conjugate is

$$(P_r + \alpha\,E_r^2) - j\,(Q_r - \beta\,E_r^2) = (\gamma + j\,\delta)\,E_s\,E_r\,\epsilon^{j\theta} \quad (7)$$

The product of the two gives

$$(P_r + \alpha\,E_r^2)^2 + (Q_r - \beta\,E_r^2)^2 = (\gamma^2 + \delta^2)\,E_s^2\,E_r^2 \qquad (8)$$

It is shown in works on the differential calculus that the envelope of such a function having E_r as the parameter determining consecutive loci, is the locus of the equation obtained by differentiating (8) with respect to the parameter E_r and eliminating E_r from the resulting equation and equation (8). This truth may not at first be evident. That it is so may be shown in a crude way as follows: Consider two power circles determined by the parameters E_r and $(E_r + \Delta\,E_r)$ respectively. As $\Delta\,E_r$ approaches zero the intersection of the two circles approaches and finally coincides with the envelope as a limit. E_r and $E_r + \Delta\,E_r$ substituted in equation (8) furnishes two equations from which the point of intersection could be calculated, two equations, two unknowns, *viz.*, P_r and Q_r. Subtracting the two equations and dividing by $\Delta\,E_r$ furnishes a third dependent equation. This third equation when $\Delta\,E_r$ approaches zero forms the differential of equation (8). It is evident then that the point of intersection or the envelope may be obtained by the simultaneous solution of one of the first two equations, *i. e.*, equation (8) and the third equation, *i. e.*, the differential. Since the envelope must be independent of the parameter E_r and since the simultaneous solution of equation (8) and its differential must be the envelope,

the latter operation may be accomplished by eliminating E_r from equation (**8**) and its differential. Differentiating (**8**) with respect to E_r

$$2\alpha(P_r + \alpha E_r^2) - 2\beta(Q_r - \beta E_r^2) = (\gamma^2 + \delta^2) E_s^2 \qquad (\mathbf{9})$$

Let

$$(\gamma - j\delta) = \sqrt{\gamma^2 + \delta^2}\,\epsilon^{j\theta_1} = \sqrt{\gamma^2 + \delta^2}(\cos\theta_1 + j\sin\theta_1)$$

$$(\alpha - j\beta) = \sqrt{\alpha^2 + \beta^2}\,\epsilon^{j\theta_2} = \sqrt{\alpha^2 + \beta^2}(\cos\theta_2 + j\sin\theta_2)$$

Substituting in equation (**6**) and equating reals and imaginaries, we obtain

$$P_r + \alpha E_r^2 = \sqrt{\gamma^2 + \delta^2}\,E_s E_r \cos(\theta_1 - \theta)$$

$$Q_r - \beta E_r^2 = \sqrt{\gamma^2 + \delta^2}\,E_s E_r \sin(\theta_1 - \theta)$$

Substituting these values in equation (**9**)

$$2\sqrt{\gamma^2 + \delta^2}\,E_r[\alpha\cos(\theta_1 - \theta) - \beta\sin(\theta_1 - \theta)] = (\gamma^2 + \delta^2) E_s$$

Now since

$$\frac{\alpha}{\sqrt{\alpha^2 + \beta^2}} = \cos\theta_2 \text{ and } \frac{\beta}{\sqrt{\alpha^2 + \beta^2}} = -\sin\theta_2$$

then $2 E_r^2 \sqrt{\alpha^2 + \beta^2}\cos(\theta_1 - \theta_2 - \theta) = \sqrt{\gamma^2 + \delta^2}\,E_s E_r$ (**10**)

This relation must be true for every point on the envelope. Now from Fig. 1 it will be seen that $(\theta_1 - \theta_2 - \theta)$ is the angle between bN and the line of center ob, $E_r^2\sqrt{\alpha^2 + \beta^2}$ is the length ob and $\sqrt{\gamma^2 + \delta^2}\,E_s E_r$ is the radius of the power circle. How can we determine the particular position of N such that equation (**10**) will also hold true? With O as center draw a circle through b. The diameter of the circle will be $2E_r^2\sqrt{\alpha^2 + \beta^2}$ and bc is $2E_r^2\sqrt{\alpha^2 + \beta^2}\cos(\theta_1 - \theta_2 - \theta)$. The point c, therefore, satisfies equation (**10**) and lies on the envelope. To determine the envelope locus lay off oc equal to ob for the different receiver power circles.

Point where Envelope Cuts Line of Centers

It is sometimes convenient to know the point at which the envelope cuts the line of centers. This point is determined when $\theta_1 - \theta_2 - \theta = O$.
From equation (**10**) we then have

$$E_r = \frac{\sqrt{\gamma^2 + \delta^2}}{2\sqrt{\alpha^2 + \beta^2}} E_s$$

The distance of the point of tangency from the origin is the radius of the $(P_r + jQ_r)$ circle or $\sqrt{\alpha^2 + \beta^2}\,E_r^2$ which is equal to

$$\frac{\gamma^2 + \delta^2}{4\sqrt{\alpha^2 + \beta^2}} E_s^2$$

This is also the smallest circle which touches the envelope.

Equation of the Envelope

Let us take the point where the envelope cuts the line of centers as origin (e in Fig. 1) and the line of centers as the X axis. The abscissa x of any point c on the envelope is then

$$x = co + ob - db$$

$$= \frac{\gamma^2 + \delta^2}{4\sqrt{\alpha^2 + \beta^2}} E_s^2 + \sqrt{\alpha^2 + \beta^2}\,E_r^2 - \frac{\gamma^2 + \delta^2}{2\sqrt{\alpha^2 + \beta^2}} E_s^2$$

$$= \sqrt{\alpha^2 + \beta^2}\,E_r^2 - \frac{\gamma^2 + \delta^2}{4\sqrt{\alpha^2 + \beta^2}} E_s^2$$

The ordinate $y = dc$

$$= \sqrt{\gamma^2 + \delta^2}\,E_s E_r \sin(\theta_1 - \theta_2 - \theta)$$

$$y^2 = (\gamma^2 + \delta^2) E_s^2 E_r^2 \sin^2(\theta_1 - \theta_2 - \theta)$$

$$= (\gamma^2 + \delta^2) E_s^2 E_r^2 \left[1 - \frac{\gamma^2 + \delta^2}{4(\alpha^2 + \beta^2)} \frac{E_s^2}{E_r^2}\right]$$

$$= \frac{(\gamma^2 + \delta^2) E_s^2}{\sqrt{\alpha^2 + \beta^2}} \left[\sqrt{\alpha^2 + \beta^2}\,E_r^2 - \frac{\gamma^2 + \delta^2}{4(\alpha^2 + \beta^2)} E_s^2\right] = \frac{(\gamma^2 + \delta^2) E_s^2}{\sqrt{\alpha^2 + \beta^2}} x$$

This equation is one of a parabola referred to its apex as origin.

Maximum Power Delivered by Line

The maximum power that may be drawn over a transmission line depends upon the line constants, generator and receiver voltage and also upon the characteristics of the synchronous condenser. With a condenser of infinite capacity the maximum power is determined when $\frac{dQ_r}{dP_r}$ is equal to infinity. From the geometry of the circle diagram this value is seen to be

$$\sqrt{\gamma^2 + \delta^2}\,E_s E_r - \alpha E_r^2$$

However, with a condenser of finite size the characteristics of the condenser must be taken into consideration.

Maximum Power Delivered by Line with Finite Condenser

Let us consider a definite case. Fig. 2 shows the receiver circle diagram of a single 220-kv., 3-phase, 250-mile line, 600,000-cir. mil copper conductor with 22 ft. triangular spacing. The condenser characteristics which we will choose for this line are represented by the full lines in Fig. 3, terminal voltage being plotted against leading and lagging kilovolt-amperes for constant field current. The transformer reactance is included in the condenser characteristics. Assuming for the time being a dead resistance load, the loci of constant field current may be plotted on the circle diagram as shown in Fig. 2. For the case in which all or part of the load consists

of inductive apparatus, the variation of reactive power with voltage must be considered in plotting the loci of constant field current on the circle diagrams. Care must be exercised in reading such a graph. The loci of constant excitation are not double valued functions of voltage, as might appear at first, since some of the curves cut the same voltage circle twice. The inter-

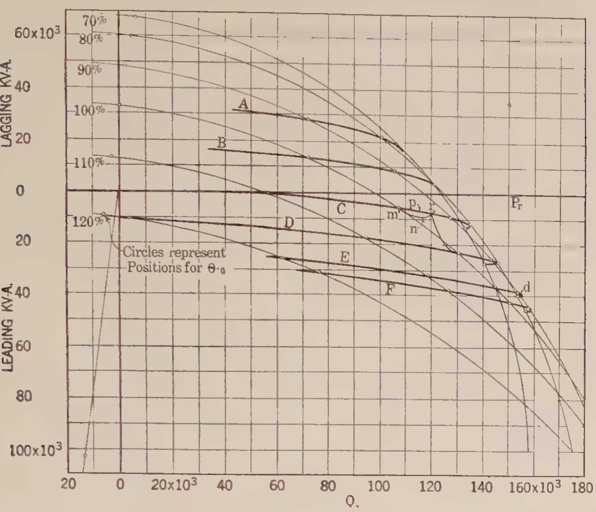


FIG. 2—250-MILE LINE WITH 35,000 KV-A. LEADING AND LAGGING CONDENSER

sections of the upper portions of the curves with voltage circles refer to the higher values of voltage while the intersections of the lower portions refer to the lower values of voltage. The maximum power that may be drawn over the line for a given field excitation is determined when $\frac{d\,P_r}{d\,Q_r}$ is zero. Another relation[6]

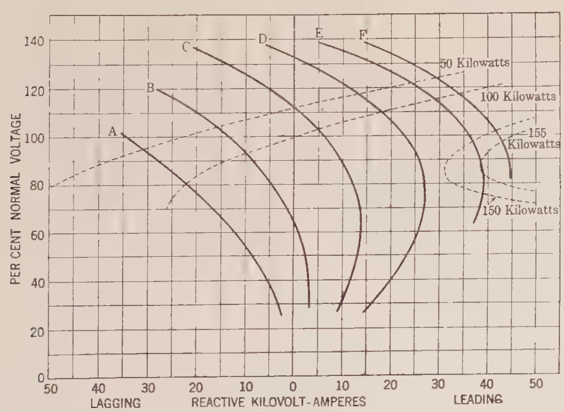


FIG. 3

Full lines represent condenser characteristics with constant excitation. Dotted lines represent reactive kv-a. relation for constant power as taken from circle diagram.

which must be satisfied at the maximum power is that $\frac{\partial\,Q_r}{\partial\,E_r}$ for the circle diagram (constant real power) be simultaneously equal to $\frac{\partial\,Q}{\partial\,E_r}$, where Q is the combined reactive kilovolt-amperes of the condenser and the load. The truth of this relation is shown graphically in Fig. 3, by plotting the values of reactive power against voltage for constant true power (dotted lines). As can be seen the maximum power which permits of a solution for a fixed excitation occurs for that value of power the curve of which is tangent to the excitation curve.

STABILITY WITH LOAD OF CONSTANT RESISTANCE

The physical significance of what occurs when an increment of load is applied may be best illustrated by

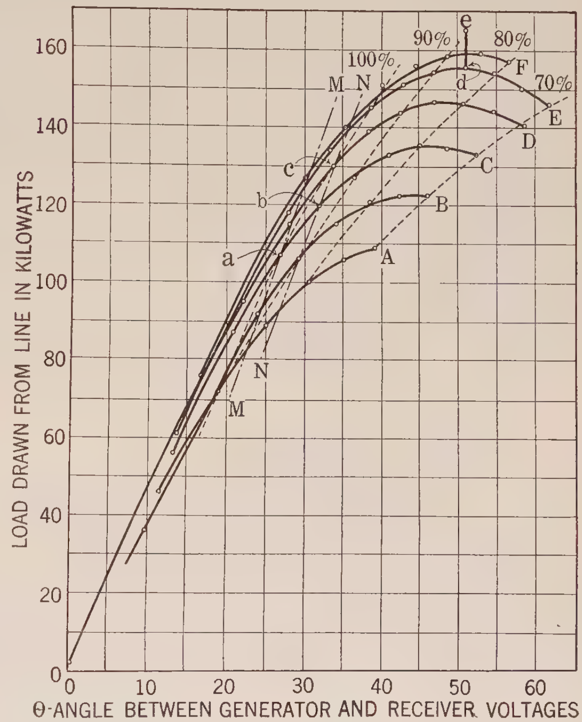


FIG. 4—250-MILE LINE CHARACTERISTICS WITH 35,000 KV-A. CONDENSER

Full line—constant excitation.
Dotted line—constant voltage.
Dot-dash—constant load resistance.

still another curve. Fig. 4 shows the synchronous condenser curves of constant field current plotted with angle between generator and receiver voltage as abscissas and power drawn from the line as ordinates. These values were obtained from the constant field current loci in the circle diagram. Fig. 4 also shows loci of constant voltage and constant load resistance for the transmission line. The former represent the relation between the power drawn from the line and the angle between the generator and receiver voltage for constant voltage and the latter express the power taken by the load as a function of the angle between the generator and receiver voltage for constant load resistance. For our present discussion let us assume the generator voltage fixed in magnitude and phase posi-

6. The companion paper by Evans and Bergvall discusses this relation in greater detail.

tion, *i. e.*, a generator of zero impedance and armature reaction.

Suppose we are operating at the point a on Fig. 4, the intersection of the curve of constant field current C, of constant voltage 100 per cent normal and of constant resistance $M - M$. Now reduce the load resistance to that corresponding to the locus $N - N$ still maintaining the same field current. The operating point tends to move to the new point b, but in doing so the angle between the generator and receiver voltages increases; *i. e.*, with fixed generator voltage the terminal voltage of the condenser lags behind its original position a. Due to its inertia the rotor is unable to follow the terminal voltage instantly. This condition requires the condenser to function as a generator and supply part of the increase in load during the period in which the rotor is slowing down to its new position approximately in phase with the terminal voltage.

The division of load between the condenser and line accompanying a decrease in load resistance (constant field current) is explained as follows. With a dead resistance load such as we are considering all of the change in reactive power even during the transition period must be supplied by the condenser. This latter quantity is approximately equal to

$$\frac{E_r^2 - E_n E_r \cos \phi}{X}$$

Where E_r = Terminal voltage
E_n = Rotor voltage
X = Leakage reactance of condenser
ϕ = Angle between E_r and E_n

For steady state and also for the small angular swings during the transition period $\cos \phi$ will be very nearly equal to unity. For our present discussion we may then assume the reactive power to be a function of X and the scalar value of E_r. This shows that the terminal voltage during the transition period must vary along a locus similar to those of constant excitation shown on Fig. 2. These new loci differ from those of constant excitation only in the fact that the latter use leakage reactance and the former use synchronous impedance. For zero leakage reactance the loci coincide with the voltage circles. The true loci lie between the loci of constant voltage and the loci of constant excitation in which the synchronous impedance were used. In this way the relation between voltage and angular position of the terminal voltage which must be maintained during the early part of the transition period is determined. After the field in the condenser has built up, the synchronous impedance must be used. To state these facts slightly differently. Suppose we are operating at the point m in Fig. 2. With a condenser of zero impedance the operating point would be constrained to lie on locus of constant voltage $m\,p$ even during the transition period. With a condenser of zero armature reactance, *i. e.*, the leakage reactance equal to the synchronous reactance the operating point would be constrained to lie on the locus of constant field current during the transition period. But with a practical condenser, as the load resistance is changed with constant excitation the operating point will be constrained to lie on the curve $m\,n\,r$. The exact curve is a complex function of time, varying as the effective reactance changes from the leakage valve to the synchronous value and also varying with the speed the rotor changes its angular position. Immediately after the load resistance is changed the operating point will jump to an intermediate point which can be definitely determined. In the determination of this point the leakage reactance shall be used.

Now coming back to Fig. 4. Suppose we are operating at the point a and the load resistance is decreased. The operating point will be constrained to move along a curve lying between the locus of constant voltage and the locus of constant excitation. With a condenser impedance other than zero the receiver voltage drops with increasing angular displacement between the generator and receiver voltage as we move along the constraint. For every value of angular displacement there is a definite value of voltage. The power taken by the load can then be determined by the relation E_r^2/R where R is equal to the new load resistance. Fig. 5A shows an enlarged view of the section of Fig. 4 in the vicinity of point a Curve $a\,d\,b$ is the receiver voltage constraint and $e\,g\,f$ is the power taken by the load. The vertical distance between $e\,f$ and $a\,d\,b$ represents the excess of the power required by the load over that supplied by the line.

Due to its inertia the rotor cannot follow the terminal voltage instantly as it moves from a. Neglecting the effect of damper windings the power supplied by the condenser for an angle ϕ lag of terminal voltage behind the rotor is equal to $\dfrac{E_n E_r}{X} \sin \phi$. Draw $a\,g\,h$ such that the vertical distance between it and $a\,d\,b$ is equal to the above quantity where ϕ is measured from a. The angle to which the terminal voltage will jump is then determined by the intersection g. At this point the excess of the power required by the load over that supplied by the line is equal to that supplied by the condenser.

In supplying this energy the rotor of the condenser begins to lag behind its original position. This requires the curve $a\,g\,h$ to move to the right taking the positions shown by the dotted lines. In doing so the intersection moves from g downward along $e\,f$, the power supplied by the rotor steadily decreasing until the point b is reached. The rotor may overshoot but oscillates about b as a limiting position.

The locus $a\,d\,b$ is drawn assuming the field had built up and developed the full synchronous reactance. The dot-dash line shows the locus when the field has not had time to develop. Under certain conditions of low-frequency oscillations in the field the operating point

might even encircle the point b. With an extremely heavy rotor the operating point will move slowly from point d and with a light rotor correspondingly faster. In the above discussion the effect of the damper windings was neglected. As soon as the receiver voltage leaves a relative motion between the terminal voltage and the rotor takes places in such a manner as to convert the condenser into an induction generator. The damper windings and induced currents in the field coils and field structure determine the rate at which the operating point moves from a. We thus have the double effect of synchronous generator and induction generator action in retarding the rotor as it moves to its position b. Beyond the point b both effects reverse,

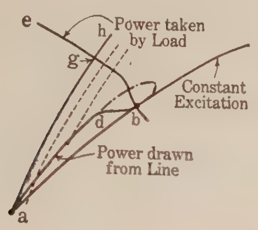


Fig. 5A

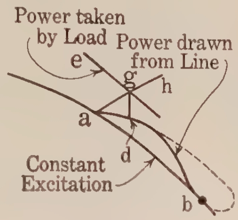


Fig. 5B

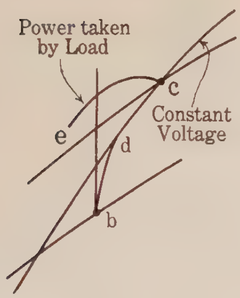


Fig. 5C

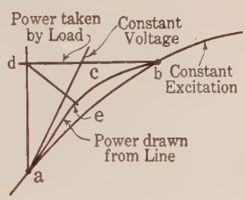


Fig. 5D

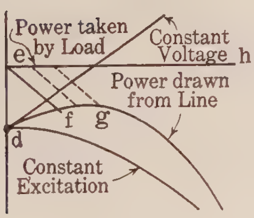


Fig. 5E

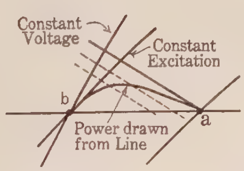


Fig. 5F

thus tending to bring the rotor back to b. There appears to be no reason in this case for suspecting a condition of instability as far as the condenser is concerned.

Referring to Fig. 2, the question sometimes arises as to the stability with a dead resistance load of operating at a point on the lower side of a locus of constant excitation. Fig. 5B shows a diagram similar to that of 5A except that it represents a point on the under side of the constant excitation locus. There appears to be no tendency toward instability. This condition alone, is then insufficient to determine the limit of instability with a dead resistance load. The true limit of instability appears to be at that point where $\frac{d\,P}{d\,\theta}$ for constant excitation is equal to $\frac{d\,P}{d\,\theta}$ for constant load resistance. If this angle is exceeded by decreasing the load resistance further the amount of power supplied by the rotor increases as the rotor lags and finally pulls out of step.

Now it will be noted that in decreasing the load resistance with constant excitation the terminal voltage drops. This brings the voltage regulator of the condenser into action. Let us then consider the distribution of power as the load resistance is kept constant and the field current is increased. Let the operating point be b Fig. 4 and increase the excitation from that corresponding to C to that corresponding to D. Fig. 5C shows an enlarged view of that part of the section. Inasmuch as it is the field of the condenser itself which produces the change, the operating point will not jump to an intermediate point immediately. The process is more gradual, the point moving from b toward c by the line $b\,d\,c$. The exact position of $b\,d\,c$ depends upon the inertia of the rotor, the magnetic circuit, etc. The power absorbed by the load is $e\,c$. This line is conditioned by the variations in voltage imposed by the locus $b\,d\,e$. The rotor in retarding supplies the differences in power designated by the vertical distance between $b\,d\,c$ and $e\,c$.

Stability with Inductive Load

The foregoing considered the conditions pertaining to a dead load. With an induction motor load which is essentially constant power independent of voltage, other factors must be considered. Taking proper cognizance of the variation of its reactive load with voltage, a set of curves similar to those of Fig. 4 can be constructed. However, for our discussion let us use the same curves.

Let us assume again that we are operating at the point a Fig. 4. Let us increase the load from that corresponding to a to that corresponding to b. Fig. 5D shows the transition period. The line $d\,b$ represents the power taken by the load. The line $a\,c$ is determined by the reactive kilovolt ampere relations that must be satisfied, (leakage reactance used instead of synchronous reactance and variation of lagging kilovolt-ampere taken by induction motor load as voltage changes). The initial operating point is constrained to lie upon this line. The vertical distance between any point on $a\,c$ and the line $d\,b$ represents the excess of the power required by the load over that drawn for the line. Draw $d\,e$ such that the vertical distance between $d\,e$ and $d\,b$ represents the power supplied by the rotor as the receiver voltage lags behind the rotor. The intersection of $a\,c$ and $d\,e$ therefor, represents the point to which the operating point will jump (neglecting damping action) as the load is increased. After this point is reached the operating point moves toward b. The exact path taken depends

upon the inertia of the rotor, the magnetic circuit, etc. There is no apparent instability.

But suppose we are operating on one of the excitation curves where the slope is zero (Fig. 4), say at the point d on excitation curve E. Suppose the load is increased to the value corresponding to that of e. Fig. 5E represents the transition diagram. The line $d\,f$ again represents the locus of constant leakage reactance, determining the initial point f to which the operating point jumps. As the rotor lags the line $e\,f$ moves to the right as shown by the dotted lines. After the point g is reached the power supplied by the retardation of rotor, *i. e.*, the vertical distance between $e\,h$ and $d\,g$ begins to increase; the affect becomes cumulative, the more the motor lags the greater the amount of power it supplies and the faster it retards until pull-out occurs. Under these conditions we may then say that stable operation results provided the excitation curve Fig. 4 has a positive slope. Referring to Fig. 2 stable operation results up to the point where $\frac{d\,P_r}{d\,Q_r}$ for constant excitation becomes equal to zero.

Changing the excitation maintaining the load constant produces a transition diagram similar to Fig. 5F This condition is likewise stable until the slope of the particular excitation curve Fig. 4 is zero.

An induction motor load has another effect. It has been observed in low-voltage transmission circuits in which the resistance is about equal to the reactance that hunting of the condenser at the receiver end takes place. It has been further observed that the presence of an unloaded induction motor tended to stabilize the line. This result may be explained as follows: In the foregoing, as instantaneous changes in load or field current occurred the receiver voltage changed instantly to a new position. However, with an induction motor, as soon as the vector of terminal voltage moves from its original position, it represents an increase or decrease in actual vector velocity. This in turn increases or decreases the slip. As a result the rotor of the induction motor momentarily takes care of the increase or decrease of the load. This occurs as soon as the voltage begins to change position. The induction motor then acts as a cushion in absorbing the shocks incident to change of load, excitation, etc. It decreases hunting but does not otherwise affect the power limit.

Considerations Involved in Extremely Long Lines

The question sometimes arises as to the stability of a condenser located at the end of an extremely long line. To investigate this point let us consider a 220-kv., 60-cycle, 500-mile line. Fig. 6 shows the circle diagram of such a line with the loci of constant excitation superimposed thereon. Fig. 7 shows data for the 500-mile line similar to that shown in Fig. 4 for the 250-mile line. Applying the same type of analysis to Fig. 7 as has been applied to Fig. 4 we may arrive at the same conclusion, *viz.*, for a dead resistance load there appears to be no apparent stability even beyond the point of maximum power for fixed excitation, but for an induction motor load the maximum load occurs when the differential of real power with respect to θ for any voltage is equal to zero. This latter condition also

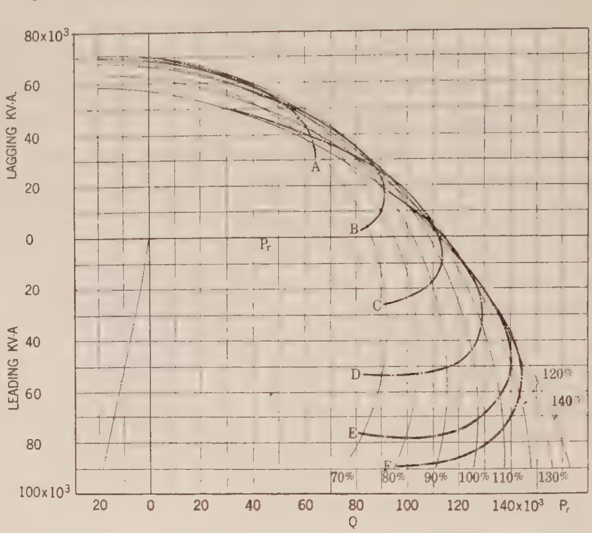


Fig. 6—500-Mile Line with 70,000 Kv-a. Leading and Lagging Condenser

requires that $\frac{d\,P_r}{d\,Q_r}$ for the locus of constant excitation be zero, *i. e.*, when the slope on Fig. 6 is vertical.

The value of plotting the condenser characteristics as on Fig. 6 may be illustrated. A condenser capable of supplying 70,000 kv-a. lagging and 70,000 kv-a. leading

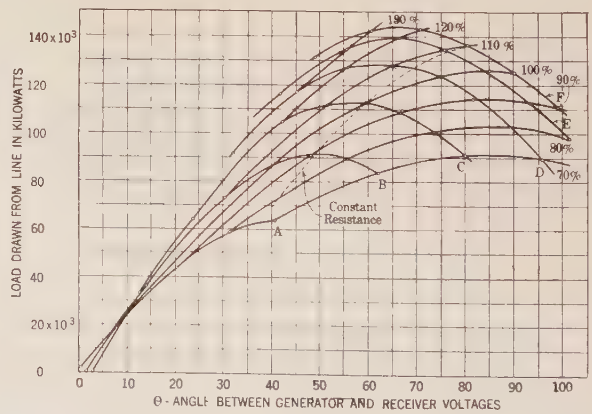


Fig. 7—500-Mile Line Characteristics with 70,000 Kv-a. Condenser

Letters refer to constant excitation. Figures refer to per cent of normal voltage.

at 100 per cent voltage was selected. From the circle diagram alone one would suppose that with 70,000 kv-a. leading capacity at 100 per cent voltage about 126,500 kw. could be drawn from the line. The actual limit, however, as determined by the slope of the constant excitation locus is 110,000 kw.

500-Mile Line with Intermediate Condenser Station

In recent years much thought and analysis have been given to the question of transmission of large blocks of power over great distances. Mr. Frank Baum,[7] in particular, has made a very comprehensive survey of our national resources, power markets, etc. His general solution of the superpower problem suggests placing synchronous condenser stations at intermediate points along the line to supply the charging kilovolt-ampere of the line, maintain constant voltage, and increase the power limit of the line. The first step in the logical development of such a system necessitates the analysis of, say, the 500-mile problem with a condenser station at the midpoint. The circle diagram for the receiving end section assuming constant 100 per cent potential at the midpoint would be the same as Fig. 2. With the given condenser, the maximum power limit at 100 per cent voltage is 151,000 kw. and for reduced voltage the power limit may be extended to 159,000 kw. The questionable element lies in the combined line and condenser characteristics at the midpoint. Fig. 8 shows the loci of constant field current for a 70,000-kv-a. leading and lagging condenser. These loci represent the relation between real and reactive power drawn from the generator section at the midpoint for constant excitation of the condensers, assuming constant normal voltage at the generator and receiver ends. The maximum power limit in this case occurs on the 100 per cent voltage circle at 175,000 kw. This value is more than sufficient to supply the losses in the receiver section. We could probably use a much smaller condenser. In practise this capacity would be built in several units. We can safely say then that the maximum power limit of the 500-mile with a condenser at the midpoint is 159,000 kw. The rated power of such a line allowing for switching power surges, let us estimate at about 120,000 kw. The actual reactive power required at this load is zero at the midpoint and about 15,000 kv-a. leading at the receiver.

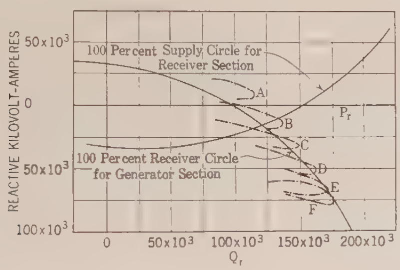


Fig. 8

Constant field current loci of condenser at mid-point of 500-mile line, plotted against power transmitted at mid-point and reactive power drawn from generator section, 100 per cent voltage at generator and at receiver.

Let us compare this line with a straight 500-mile line. Examination of Fig. 6 will show that little can be gained by supplying leading reactive power at the receiver. Let us assume then the power limit to be 115,000 kw. at zero reactive power. The rated power on the same basis as above, *viz.*, 75 per cent of maximum power would be about 86,000 kw. The active reactive power at this load at the receiver is 29,000 kv-a.

What have we gained? The rated capacity of the line has been increased from 86,000 kw. to 120,000 kw. an increase of 40 per cent. At the same time the condenser capacity required at these loads has been decreased from 29,000 kv-a. to 15,000 kv-a.

What has it cost? The no-load synchronous condenser capacity is practically unchanged. For the simple line the no load reactive power is sufficient to regulate up to the maximum power limit assumed, but the "compound" line requires 35,000 leading kv-a. at the receiver for load conditions in addition to the 35,000 kv-a. lagging at no load. The midpoint also requires about 70,000 kv-a. leading capacity under load conditions in addition to 70,000 kv-a. lagging under no load. But the greatest disadvantage is the housing of the condensers at the midpoint with all the necessary switching facilities. This last point should, however, be greatly discounted by the greater reliability of service obtained. It is quite improbable that a 500-mile line would be constructed without providing appropriate switching facilities at the midpoint to provide for emergency conditions. Mr. Frank G. Baum has pointed out other advantages of the intermediate condenser station.

Considering the pros and cons it is apparent that the increased line rating and reliability of service is well worth the additional condenser station equipment. For longer lines the need for intermediate condenser stations is still more pronounced. The exact number of stations in longer lines rests upon the economy of the situation,—the amount of power that can be sold, the cost of power at the power-house bus bars and similar questions affecting the problem.

Conclusion

The writers have attempted to bring out the following points:

1. A proof of the circle diagram has been given maintaining therein the idea of the angle between the generator and receiver voltages.

2. A graphical means for the determination of the envelope of the receiver power circles and an analytical proof showing the envelope to be a parabola with its axis as the line of centers of the circles.

3. It has been shown how the characteristics of the synchronous condenser limit the maximum power that can be transmitted over a line.

4. The effect of character of load on stability has been discussed.

5. The characteristics of a 500-mile line have been discussed and compared with the characteristics of the same line with a condenser station at the midpoint. This comparison resulted very favorably for the latter combination.

7. Atlas of U. S. A., *Electric Power Industry.*

Recent Advances in the Design, Manufacturing and Testing of Static Condensers in Power Sizes

BY R. E. MARBURY
Asscoiate, A. I. E. E.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Review of the Subject.—*The static condenser is particularly desirable as a power factor corrective device since it requires no attention. To fully capitalize this advantage static condensers must be reliable.*

The reliability of insulation subjected to a constant potential stress, depends on the ratio between the working stress and the disruptive stress.

This ratio has been kept large in all electrical apparatus and years of successful use have followed.

Static condensers are described, which have been designed with insulation factors of safety such as have proved dependable in other apparatus for years.

These ratios have been maintained and the product still kept on a reasonable commercial basis by increased economy in construction and use of material and by accurate check of insulation quality in every unit.

* * * * *

A STATIC condenser is a device for storing electrostatic energy. It is similar in characteristics to an inductance, which stores electromagnetic energy, except that the energy stored and returned to the line is 180 deg. out of phase with the energy stored and returned by an inductance.

The static condenser is an ideal device for compensating for the lagging power factor of inductive loads since the energy for the magnetic field is stored locally as it is released, and is returned at the proper time to rebuild the magnetic field. The line is thus relieved of the need for handling anything but power current.

Wherever insulation is subjected to a potential stress

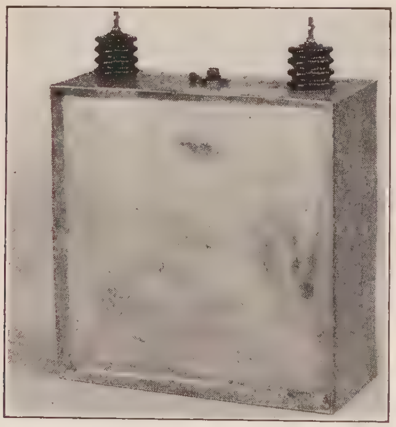


FIG. 1—2 KV-A., 2300 VOLT, 60-CYCLE CONDENSER UNIT TYPE "L. D."

Case dimension 6″ x 13½″ x 13½″. Working stress 145 volts per thousandth of an inch.

as is the case with all electrical apparatus, a static field is established therein. If this potential stress is alternating, electrostatic energy is stored and returned to the source every half cycle. Insulation has been used for years to space electrically current carrying parts. In most cases its function is not only an electrical separator, but also a mechanical separator. Often times the mechanical stresses control the design of insulation, especially where large bodies of metal come in contact with it while expanding and contracting, or when it is subjected to bending or vibration. In addition to the mechanical and electrical stresses placed upon it, it is usually called upon to operate at relatively high temperature. Because in most apparatus, such as transformers, motors and generators, the insulation cost is relatively low as compared with that of other materials, and because the cost of assembly is great, high working stress for the insulation results in

FIG. 2

Sample of thin paper manufactured to be free from holes. The holes in the paper are photographed as black specks by special process. Many of the holes are caused by the pulp being drawn through the screen used in manufacture. The image of the screen may be seen in the arrangements of holes.

little saving in unit cost, while the occasional failure introduced causes a considerable contingent loss. The condition for greatest manufacturing economy for such apparatus is thus the use of low working stress for the insulation.

When the purpose of the insulation is to store

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924.

electrostatic energy as in the case with a condenser, the whole situation changes. Here the only active material is the insulation. All accessories such as bushings, case, packing, etc., contribute nothing toward the storing of energy. The insulation, therefore, must for best economy, be worked at or near the maximum safe stress over the entire area.

Early in the development of condensers it was recognized that the conditions under which insulation is used in condensers are more favorable than in other electrical apparatus. The condenser units for power factor correction consist of four stacked sections connected in parallel and assembled in a vacuum tight sheet steel case having one opening for impregnation.

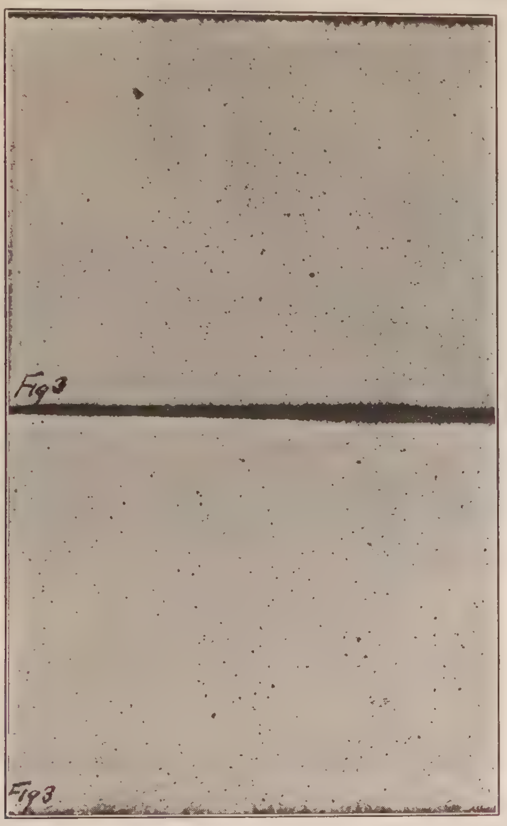


Fig. 3

Samples showing holes in the average thin paper manufactured carefully to be as free of holes as possible.

The sections are made by the inter-leaving paper and metal sheets, alternate sheets of metal extending in opposite directions and soldered to form opposite polarity terminals. Conductors are smooth plates, with no mechanical vibration or bending. Moisture can be more easily removed, thorough impregnation effected and low losses obtained. The operating temperature of the material is very low since the only losses are dielectric losses. The units are entirely filled with oil and sealed, this preventing air or water from entering the insulation during shipment. Early attempts to capitalize on these more favorable conditions led to the construction of condensers designed to work at voltage stresses many many times greater than those used in other apparatus. Laboratory samples have been made to operate thousands of hours at 1100 volts per thousandth of an inch, while commercial units designed with stresses of 400 volts per thousandth of an inch have operated over long periods of time.

When such high dielectric stresses are used, a number of manufacturing difficulties arise. For

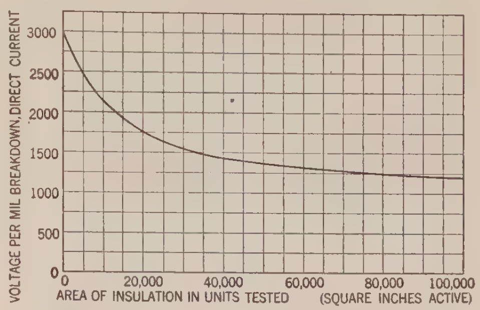


Fig. 4

Curve showing the large variations in breakdown voltage of thin condenser tissue, with area involved in the condensers tested. Tests are made on the unimpregnated material to limit variations to those caused by porosity and foreign conducting particles.

relatively low voltages such as 2300 high stresses mean thin dielectrics between plates. Thin dielectrics with high stresses necessitate utilizing the barrier action of the paper to increase the ultimate strength far beyond that of the oil alone. In order to make use of the barrier action of the paper over large areas of insulation

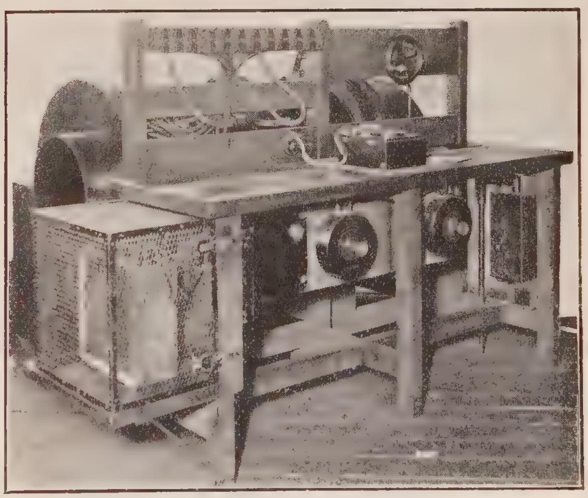


Fig. 5

Equipment for measuring dielectric losses at rated voltage and frequency. The air core inductance is shown at the rear of the rack. The condenser on test is shown in the screened enclosure. The variometer on the right is operated by the handwheel, through a worm reduction.

practically perfect paper is required. The quality is, therefore, largely dependent on porosity in this case.

In addition to the structural requirements the paper must be practically free from metal particles since with very thin dielectric material the size of the conducting

particles is quite comparable to the dielectric thickness and the percentage increase in stress on the insulation where they occur is very great. The difficulties encountered due to metal particles lining up and reducing the breakdown or due to porous paper, increase with the size of the units due to a law of averages and the size of units that can be manufactured on the high stress basis is very limited.

The net result of the early development work using very high stresses showed that it is possible to over capitalize on the more favorable conditions and that we should not lose sight of the practical conditions that have caused us to choose the conservative insulation stresses used in other apparatus. Certain tests have been established which are conceded to insure a sufficient factor of safety for insulation in ordinary apparatus. These tests are based not only on the operating voltage, but also take account of abnormal overvoltage and surge conditions which occur in service. Since the condensers are to operate under conditions very similar to those on which the established tests are based, it is clear that condensers which pass these tests will have the same factor of safety as other apparatus so tested.

It has been found that, due to the high quality of insulation that can be put into condensers less insulations can be used to meet these established test requirements, than in the case of other apparatus. The standard test applied to all static condensers of our present design is 2¼ times normal operating voltage plus 2000 volts for one minute. Advantage has been taken of the more favorable conditions under which condenser insulation is worked, only to the extent that, while the standard test requirements have been met, it has been done by using less insulation and working with higher dielectric stresses than would

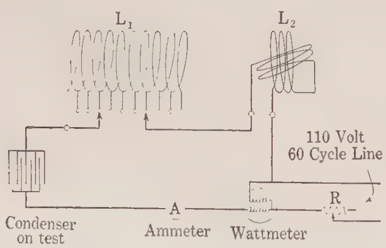


Fig. 6

Diagrams of connections of dielectric loss measuring equipment.

be desirable under the conditions with ordinary power apparatus. Moreover a much greater factor of safety is obtained due to the high quality of material as will be seen from the fact that the average 2300-volt condenser breaks down at 12,000 to 18,000 volts.

The use of large amounts of working material necessary to these low stresses has been made economically feasible by refinements in design which eliminate all unnecessary material and accessory parts as well as the reduction of cost of the paper itself. Since condensers are practically all insulation their cost is directly proportional to the insulation cost and a minimum can only be obtained by using material that gives maximum dielectric strength per dollar invested in insulating material. This does not necessarily mean that the most expensive material is the most economical as the electrical quality of the paper does not increase as rapidly as its cost when attempts are made to produce ideal material. When the cost of the material is plotted against electrical insulation value it is found that the

Fig. 7

Three 2-kv-a. units which have operated continuously on a 2200-volt line directly exposed to all weather conditions for over a year.

highly refined materials are not commercially justified and in condensers just as in cable, transformers other apparatus the quality of the material is not so important as the relation between quality and cost. The selection of material is, therefore, an economic study.

An investigation was made as to the exact characteristics required in the paper with the object of reducing the cost due to unnecessary and expensive refinements. This, together with experience over a considerable period has resulted in the use of a very pure wood pulp paper that can be carefully controlled commercially, in so far as foreign materials and quality are concerned.

In carrying out the impregnation of the units, they are assembled along a pipe manifold by means of the pipe thread connection in the center and placed into an oven at 125 deg. cent. Moisture is removed by vacuum and oil is put in while vacuum is maintained. The entire process requires 100 hours. During the treatment over one pound of water is removed from 22 pounds of paper in each 2-kv-a. unit. The process cannot be completed on units having leaks which insure

oil tight units when completed. In order to check the degree of moisture removal before running the oil in a test is made for rate of water omission by means of a liquid air trap.

After the units come from the impregnating ovens they are measured for capacity, the exact values being stamped on the nameplates. They are then tested for dielectric losses first to insure that the impregnating process has been carried out properly and second to maintain the quality from the standpoint of power loss in service. After the losses are measured and it is established that the units are of proper quality each is given an over potential test of 2¼ times rated voltage plus 2000 for one minute. This is r. m. s. voltage and the tests are made on 25 cycles to reduce the loss in the metal parts in the condenser.

The average dielectric loss is ½ of 1 per cent of the kilovolt-ampere. There are many ways of measuring

FIG. 8—36-KV-A., 3-PHASE, 60-CYCLE, 2200-VOLT EQUIPMENT

losses on high voltages at practically zero power factor, but most of them require the use of delicate instruments and extreme care in the handling. For commercial use a method is needed by which every unit can be quickly and accurately measured so that the quality of the product can be closely controlled. The development of such a measuring device has contributed greatly toward the solution of the problem of condenser manufacture.

At the present time such an equipment is in use. The loss is measured under operating conditions with an error of not more than 3 per cent, and less than one minute per condenser is required for the measurement. An inductance of approximately 6 henrys for 2300 volts 60 cycles and having only about twice the loss as the condenser, is connected in series with the condenser to be tested. A 60-cycle voltage is applied and a portion of the inductance which is constructed as a variometer is adjusted so that the whole circuit has roughly unity power factor. The current is adjusted so that the condenser operates at its rated kilovolt-ampere and the loss measured by means of an ordinary wattmeter. By reference to the calibration curve of the inductance, the inductance losses are determined

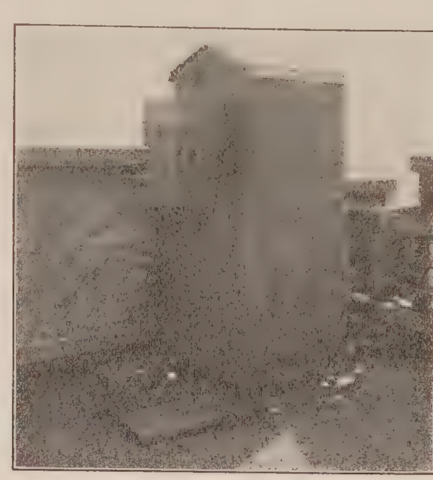


FIG. 9—36-KV-A., 3-PHASE, 60-CYCLE, 2200-VOLT OUTDOOR INSTALLATION

for the particular current used, and these are subtracted from the total leaving the loss in the condenser.

The inductance was calibrated by means of a pyro-electric wattmeter. This calibration was double-checked by measuring the losses of the inductance and a condenser separately at the low power factors, and then connecting them in series and measuring the

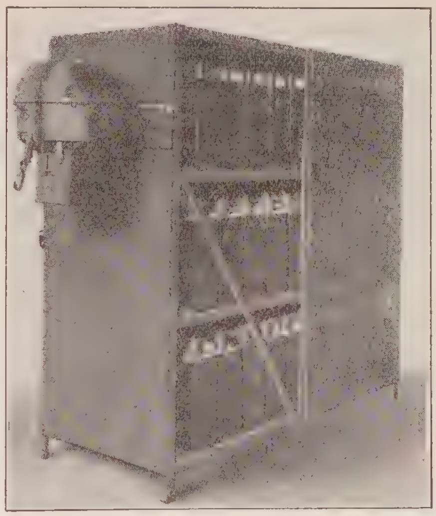


FIG. 10—120-KV-A., 3-PHASE, 60-CYCLE, 2200-VOLT EQUIPMENT

losses at unity power factor. Extremely accurate tests were made and the sum of the first two checked the third. Such checks were made over the whole working range of the equipment. This establishes the accuracy of the method of measurement.

To meet the various application requirements

assemblies are made of units mounted in structural steel frames and enclosed by expanded metal screens. On the front panel of each is mounted a standard circuit breaker the leads of which connect to vertical bus bars behind the panel. Connections are made between these vertical bus bars and the units with small copper straps to form star, delta or two-phase circuits. The units in the frames are connected to one another by short copper links which may be removed to cut out any desired number of units when seasonal changes of load demand less corrective kilovolt-ampere.

Four standard frame sizes are available for maximum capacities of 36, 60, 96 and 120 kv-a. respectively. These frames are identical except for the depth which varies to accommodate different numbers of units. Larger installations are made up of combination of these standard frames arranged as desired and connected in parallel. This provides great flexibility in application and also permits change of correcting kilovolt-ampere by simply operating the breakers on the individual frames. With large outfits such as 600 and 1000 kv-a. this is very desirable.

Although the obviously large and growing field of application for dependable static condenser equipments has been at times a temptation to begin commercial manufacture prematurely it is now felt that it has been best to delay for complete assurance of quality backed by close control of materials and process with reliable and accurate checks at all stages of manufacture and with test standards for factor of safety of insulation strength which are in general use and which have been proved to insure good service.

Power Plant Auxiliaries and Their Relation to Heat Balance

BY A. L. PENNIMAN, Jr.
Associate, A. I. E. E.
Consolidated Gas, Electric Light & Power Co., Baltimore, Md.

Review of the Subject.—*In the larger central station steam plants, efforts to increase the over-all economy and ease of operation were responsible for the use of motor-driven auxiliaries receiving their power from auxiliary turbogenerators, called house turbines, the exhaust from which is used for heating feed water. This scheme is reliable and economical. It is handicapped by the fact that over a considerable range of load some of the auxiliary power must be taken from the main bus or some of the energy generated must be fed to the main bus. This resulted in transfer motor-generators, etc., which were additional complications.*

Still greater economy is possible by bleeding steam from the low-pressure stages of the main unit to heat the feed water. Considerable heat that would otherwise be rejected with the condensing water is reclaimed, thereby allowing of a smaller condenser than would otherwise be required, the performance of the main turbine also being improved due to somewhat relieving the congestion of steam in the low-pressure stages.

To utilize fully the advantages of stage bleeding, the auxiliary power must be obtained from the main turbine. In order to insure an uninterrupted supply of auxiliary power to the essential drives it is suggested that an auxiliary generator be connected to and driven by the main turbine, thereby supplying the necessary reliability as long as the main turbine is available for load.

Due to the advantages of variable speed drive for circulating pumps, boiler feed pumps, etc., and the necessity of having direct current for excitation, a direct-current generator may be used to advantage. The use of the direct-connected auxiliary generator with stage heating, gives a maximum of flexibility, is especially reliable in that it entirely eliminates all small turbine and gear troubles, and permits of the use of the unit scheme of grouping and supplying auxiliaries, with what appears to be a maximum of economy at no apparent increase in cost.

Furthermore, the use of closed heaters with the fresh water storage located within the condenser hot well seems to offer an economical and highly satisfactory solution for the de-aeration of the feed water and to eliminate the possibility of the water picking up further air after leaving the condenser.

THE steam power station designer is confronted by the following basic requirements:

1. Maximum reliability is essential for the existance of the enterprise.

2. Economy demands that the station heat cycle approach the Carnot cycle as nearly as possible. This results in getting the maximum percentage of heat units fed into the furnace delivered to the station bus in the form of merchantable power.

3. Simplicity and flexibility of operation so that the calculated results may be obtained with minimum effort under wide variations in load, temperature and in the quality of fuel obtainable.

4. The proper balance must be maintained between initial outlay and cost of fuel so as to produce power at the minimum net cost per unit, including fixed charges as well as operating expense.

The all-steam-drive type of auxiliaries has been developed to a high state of reliability. It is economical at that station load which will utilize all of the exhaust steam. The economy decreases with the load, becoming very uneconomical at low loads. Where turbine drive is used, the economy of the auxiliary turbine falls off with reduction in speed. This is an important con-

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924.

sideration, as the demand on practically all auxiliaries decreases with the load on the station. The cost of auxiliary steam and exhaust piping is quite a factor inasmuch as the surface exposed to radiation is large. With the advent of higher steam temperatures, the reliability of the auxiliary turbines will be decreased, while the first cost and maintenance cost will be greater.

The all-electric-drive with power obtained from the station bus is simple to operate, but is not reliable as any disturbance on the transmission system may affect the station auxiliaries. Electric motors and controls have been developed to a high state of perfection and of themselves are very reliable, take up a minimum of space and require but little attention, the maintenance cost being lower than is the case with steam-driven auxiliaries.

The feed water may be heated by bleeding the main unit to open heaters which except in the case of specially designed turbines is not very economical unless bleeding takes place at several points so as to always bleed the steam at slightly above atmospheric pressure with variations in load. Special bleeder valves must be used in order to insure the safety of the unit in case of total loss of load.

Efforts to obtain the reliability of steam drive without the attending disadvantages, together with the advantages of electric drive without the questionable reliability of securing the current for motors from the main bus, resulted in the house turbine which has the additional economical advantage of lower water rate than individual steam auxiliaries, due to their relative size, which is further augmented when the house turbine is operated at partial vacuum. The house turbine gives a clean layout due to the absence of numerous steam and exhaust lines, is reliable and simple to control. The water rate is not so good as that of the main unit and the dual transformation of power from mechanical to electrical and back to mechanical is seldom more than 80 per cent efficient. Due to the advantages of variable speed drive which is most economically obtained by the use of d-c. motors, the house turbine must either drive a d-c. generator through a reduction gear with its attendant disadvantages or a rotary convertor must be used which still further reduces the efficiency of conversion.

Inasmuch as all efforts for economy point towards the utilization of low-temperature heat and towards the most economical source of auxiliary power, attention in both cases is directed to the main unit.

The main unit is inherently more economical than any of the smaller auxiliary turbines or the house turbine. In it the steam expands to the lowest pressure compatible with the available condensing water. Obviously, therefore, if steam is bled from a number of successive stages of the turbine and used to heat the feed water which is passed successively through surface heat interchangers, the power obtainable from a given amount of steam will be greatest when that steam is bled at the lowest pressure, and the power obtainable per lb. of steam will decrease as the pressure at which the steam is bled increases. Inasmuch as the condensate is usually cooler than the exhaust steam entering the condenser it would be most economical, theoretically, to bleed steam from each of the lower stages of the unit. Practical considerations will probably limit the bleeding to three or possibly four stages, the highest temperature stage being able to deliver relatively hot feed water at light loads. It must be remembered that steam bled from the main unit decreases the congestion in the low-pressure stages of the turbine, thereby improving the total performance of the unit somewhat and also decreases the duty on the condenser.

It is quite probable that still greater amounts of low head heat can be bled from the turbine prior to rejection to the condenser and used to preheat combustion air for the boiler furnaces. While bleeding steam to preheat air is somewhat novel and requires some further development of heat interchangers for this purpose, it shows considerable thermal gain. Present types of stokers using forced draft can handle air up to a total temperature of several hundred degrees Fahr. without any great difficulty. Complications would undoubtedly result from the attempted use of 300 deg. air on pulverized-coal-fired furnaces where air-cooled furnace walls are used. In the writer's opinion, however, the air-cooled powdered coal furnace is destined to be short lived, due, first, to the fact that it is obviously uneconomical to allow high head heat, which should be utilized directly for generating steam, to be used for preheating furnace air when there is so much low head heat readily available; secondly, the air-cooled furnace has not been entirely successful, the furnace maintenance undoubtedly being very high and the time the boiler is out for furnace repairs must be a considerable percentage of the service hours. The solution of this question would seem to lie in the development of a boiler and furnace so designed that the water heating surfaces absorb a large percentage of the heat which is now taken up by the furnace walls. This will allow of still higher furnace temperatures with the attending increase in efficiency.

It would, therefore, seem that the greatest opportunity for economy lies in the use of power from the main unit for auxiliary drive, this power being applied as directly as possible, together with the use of the maximum economical amount of low-temperature steam bled at several points from the main unit. The question now arises as to whether this scheme provides the essential flexibility and ease of operation.

By the use of motors it is possible to obtain compact drives, reduction gear troubles are eliminated and the mass of auxiliary steam, exhaust and water-cooling pipes is eliminated. Where d-c. motors with field control for speed variation are used there is no appreciable decrease in economy of the drive with decrease

in speed. When properly designed ball bearings are used, practically no attention is required and the units may be started, stopped or the speed varied from remote points. The steel industry has investigated the ball-bearing motor very thoroughly and have made out a very strong case in its favor. Due to their location it is desirable to be able to control the speed of forced and induced draft fans and the stoker and clinker grinder motors from the boiler room firing floor, and they are usually so located as to make it impracticable to give them relatively continuous attention without having special attendants at the several elevations where they are located. Boiler-feed and house-service pumps should also be capable of operating under the control of automatic regulators with a minimum of attention. Variable-speed d-c. motors lend themselves to this form of control just as readily as do steam turbines without the attendant change in economy with change in speed and without the attention and troubles incident to turbine packings, bearings and the possibility of damage due to overspeed on account of loss of load.

When the extra storage of boiler water is located in the hot well of the condenser and the makeup admitted directly to this hot well it is feasible to keep the water in the hot well at the temperature of the exhaust steam by raising the temperature of the hot well by the condensate from the lowest temperature feed heater, plus some additional steam bled from the last stage of the main turbine when necessary. This eliminates the use of de-aerating aparatus and makes possible the location of the make-up float valve so that it is readily accessible to the condenser attendant who can also look after the boiler feed pumps. The division of duty between the hot-well pumps and boiler-feed pumps can be so arranged as to allow minimum water pressure on the closed heaters compatible with reliable operation. The hot-well pump can be run at constant speed, the total speed variation being taken care of by the boiler-feed pump. The duty on the circulating pump can be varied to compensate for changes in load and of circulating water temperatures. This eliminates the necessity for the use of two pumps of reduced size, one being used for cold water or light loads, two for warmer water and high load; it being possible to obtain somewhat better performance by using one pump and varying the speed. Where two pumps are used for added reliability it is more economical to run both at reduced speed than to shut one down and speed up the other. Practically the same reliability can be secured by interconnecting the discharge lines on adjacent condensers and providing somewhat larger driving motors, thereby enabling one pump to serve two condensers in emergency with only a slight reduction in vacuum. By the use of a properly-designed motor the large low-speed circulating pump becomes the most reliable piece of auxiliary equipment.

The static or steam jet type of vacuum pump has proved very reliable in marine service and is becoming increasingly popular in central station service. When equipped with inter and after condensers, using condensate, and located respectively before and after the low-temperature bleeder heater, they provide a compact and reliable unit whose performance compares very favorably with a hydraulic or reciprocating air pump at a somewhat smaller first cost, and should show a lower maintenance cost and require less attention than either of the other types. The air and non-condensible vapors from the bleeder heaters can be discharged directly to the inter-condenser thereby lowering the duty on the primary jets, which should use the minimum of steam possible as it is desirable from an economical point of view to do nothing which will limit the amount of steam bled from the main unit to the low-temperature heater. Most of the operating difficulties experienced with steam jet air pumps have been due to poor performance on the part of the reducing valve supplying steam to the jets. This may be entirely eliminated by the use of a properly-designed orifice installed in parallel with either a hand or solenoid operated valve which may be opened either manually or automatically in case of a drop in steam pressure.

Since stage bleeding together with electric drive offers opportunity for higher efficiency with a maximum of flexibility at a cost as low or lower than with any other form of auxiliary drive, it now remains to provide an arrangement for obtaining power from the main units in such a manner as to guarantee continuity of auxiliary power supply eliminating all chance of trouble on the main bus being transmitted in any manner to the auxiliary bus.

All power plant auxiliaries fall into three general classes with respect to the necessity of their having a continuous power supply.

First, equipment which does not require a continuous power supply, such as coal and ash handling equipment, circulating water screens, sump pumps, machine tools, etc. This class of equipment can be eliminated from the present discussion as continuity of service is not essential.

Second, the auxiliaries which are needed only when the station is carrying load and which have to be shut down in case of an interruption which greatly reduces the plant load. To this class belong forced and induced draft fans while coal feed and clinker grinder drives might well be included as they are normally supplied from the same circuits as supply the fans. As it is essential to check the fires as soon as a general interruption occurs it is an advantage to have fan motors trip out due to low voltage. Where automatic starting panels are used, the service is automatically restored as the main bus voltage comes back. In actual practise following a general interruption the station load does not come back immediately after the restoration of full voltage it usually being at least ten minutes after the restoration of service before the load is normal. This allows ample time for furnace conditions to become

normal. Where the nature of the interruption is such as to result in low frequency and somewhat lowered voltage, trouble may be experienced in holding the motors on the line due to the operation of the low-voltage relays. This can be readily overcome by arranging to throw the affected motor controls on the station control battery. The individual controllers can then be brought up to full speed setting until the trouble is cleared, should this be necessary. Where the total number of boilers is comparatively few the contactors can be provided with a mechanical latch which will hold them in the full-speed position.

It is of course essential that the proper safeguards be used to minimize interruptions due to failure of the transformers, circuits and switching equipment between the main bus and the several motors.

The writer has operated a fairly large generating station for about five years where the boiler auxiliary drives were fed from the main bus. There have been in that time the usual number of system interruptions and

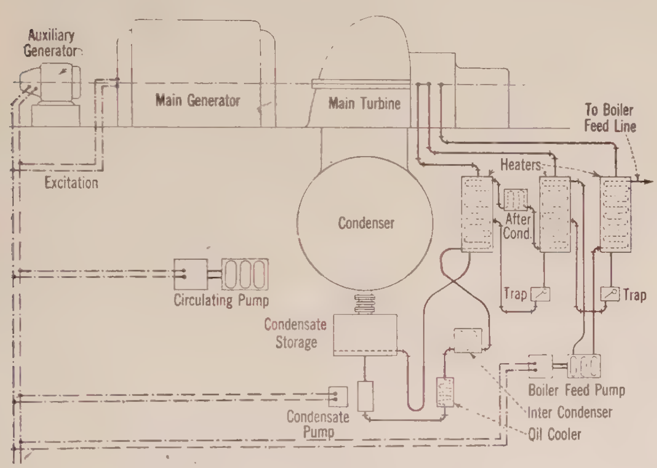


Fig. 1

disturbances without in a single instance causing any embarrassment due to inadequate power for the stoker fan and coal feed motors. It is the regular practise to have in service two banks of transformers either of which is of sufficient capacity to carry the essential service. The two transformer banks are supplied from either end of the main bus, each serving one-half of the auxiliary circuits and the other plant auxiliary load. The transformers are protected by necessary relays. The switches are so interlocked that if either high-tension transformer switch opens the corresponding secondary switch opens which in turn causes the switches supplying the non-essential auxiliary circuits to trip and parallels the two sections of the low-tension station service bus.

Third, the auxiliaries, which it is essential to keep in service in order to insure continuity of service and which it is essential to keep in service during times of interruption, are the exciters, boiler feed pumps and circulating pumps. Where the boiler-feed make-up storage is a part of the condenser hot well it is also essential that the hot-well pumps be kept in service.

The service for this third class of auxiliary drive can be most economically and advantageously supplied by a separate generator connected directly to and driven by each of the main turbine units.

Direct-connected exciters have been in quite general use for a number of years and have been so satisfactory that there seems to be no reason why the size of this piece of apparatus should not be increased sufficiently to take care of the additional load imposed by the so-called essential auxiliary drives. This auxiliary generator need be relatively small, in fact only about two and one-half per cent of the capacity of the main unit. This arrangement will require, as does the direct-connected exciter some auxiliary source of power for starting up. This can be taken care of by a motor generator, supplied from the house service transformers which if necessary can be equipped with a non-condensing turbine, exhausting to atmosphere, for starting up in case of a complete shutdown of considerable duration.

The attached sketch shows such an arrangement for a 25,000-kv-a. unit. The auxiliary generator is rated at 500 kw. 250 volts direct current. A 3000-gallon water storage will be provided in the condenser hot well. Three-stage bleeding will be used, the condensate from the high and intermediate temperature heaters will be trapped back to the next lower-temperature heater while the low-temperature heater condensate will be trapped back to the hot well where it will be used to heat the condensate and make up to the boiling point in order to drive off entrained air.

It will be noted that this scheme provides auxiliary power from the most efficient source, allows of the most economical scheme of feed heating without any complications. The auxiliary wiring is on the unit principle, the auxiliaries and generator being grouped together do not require long runs for low-voltage auxiliary feeders and there is no transformation loss in obtaining direct current for these drives. Careful analysis would seem to indicate that this scheme provides the necessary reliability without calling for any compromise that affects the economy of the general layout, at a first cost no greater, if not actually less than any of the arrangements in general use, with a maximum of flexibility of operation at varying loads, with a minimum of operating attendants.

COAL MINE ACCIDENTS

Statistics published by the U. S. Bureau of Mines for the year 1922, show that 340 people were killed underground by mine cars and locomotives, while only 32 were killed at the surface by such equipment. While undoubtedly space and other factors has considerable influence, it would seem that darkness may be an important cause of the heavier loss underground.

Carrier-Current Telephony on the High-Voltage Transmission Lines of the Great Western Power Company

BY JOHN A. KOONTZ, Jr.
Great Western Power Co., San Francisco, Calif.

Review of the Subject.—*This paper includes a brief description of the power circuits and radio equipment used in the carrier-current system; the method of calling employed, and use of this system as a trouble detector and recorder of switch operation.*

THE reports of successful tests with high-frequency telephony early interested the Great Western Power Company, and experiments were undertaken to determine whether suitable equipment could be obtained for installing carrier-current communication on our 100-kv. circuits. This equipment was later installed at the Dispatcher's office in Oakland, at the Big Bend Power Station and the Caribou Power Station.

The distance from Oakland to Big Bend via the tower line is 153 miles and from Oakland to Caribou 193 miles. Three circuits run from Oakland to Big Bend, twin circuits being carried on one tower line and a third circuit designed for 165 kv., carried on a second tower line. These two tower lines with their three circuits are located on the same 100-foot right of way for 85 miles. The twin circuits stop at the Big Bend Power House and only the 165-kv. circuit extends for the remaining 40 miles to the Caribou Station.

Under present conditions these lines are operated in parallel at the same voltage, and are in general paralleled at Big Bend, Brighton and Oakland. There are a total of nine substations tapping these lines, one of these substations being located on a short branch line.

From this brief description I think it will be readily apparent to one familiar with power carrier-current work that this is an extremely difficult system on which to place carrier-current communication. Radio engineers who are familiar with this line of work estimate that each substation is equivalent to adding at least 10 miles to the length of line and a tap line may add even more. With this in mind it is easy to see that we have an equivalent transmission distance of about 300 miles. These radio engineers acknowledge this to be the most difficult system on which they have as yet worked.

Early experiments readily demonstrated the fact that 50-watt sets were far too small for this network of circuits. 250-watt sets were then installed and it was found that at certain times this was not sufficient power to give proper communication, so these sets were modified at Caribou and the Dispatcher's office, using two 250-watt tubes in the oscillating circuit with one 250-watt modulating tube. This equipment has been in operation for about one year and has given good service. There have been a few cases of trouble but these have been few and not serious.

This system of communication apparently has many good points in connection with obtaining communication with water power plants which are situated in regions remote from the regular telephone communication. Any single telephone circuit as constructed either by the power or communication companies would be much more susceptible to mountain storms than the rugged tower circuits, and it is practically always the communication circuits that first show distress during severe storms. We were pleased to go through this last winter without a single total interruption in communication between the Dispatcher's Office and our water power stations.

At first an elaborate call bell equipment was planned and a relay was actually developed which worked very satisfactorily, but it was later found that by picking up the transmitter and placing same in the loud speakers, this particular combination would resonate to produce a howl in the loud speaker at the distant end, the frequency of which was much higher pitched than any noises around the power station and was easily detected above the power house noise.

This gave a mode of signaling without adding any additional equipment, and by simply operating the hook switch on the transmitter, code signals could be readily sent. This method of calling has proved quite satisfactory.

Because of our complex circuit arrangement we obtain at times an echoing effect in our receiving. This is possible due to the carrier current flowing along lines that have different characteristics, producing different attenuations, or due to reflection. There is, however, one very peculiar thing about this effect, and that is, often by shifting a substation from one of the twin circuits to the other the effect will be eliminated, and to date we seem to have no reasonable explanation of why this change should eliminate the trouble.

The general equipment consists of a 2000-volt, 3-wire, d-c. generator for producing suitable plate voltage for the tubes, 1000 volts being placed across the 50-watt amplifier tube and 2000 volts across the 250-watt tubes. Filaments are lighted from alternating current with rotary converters provided for supplying this current from the station storage battery

Presented at the Pacific Coast Convention of the A. I. E. E., Del Monte, Cal., October 2-5, 1923.

should there be a failure in the a-c. supply at the Dispatcher's office.

The Simplex System of communication is used, it being necessary to operate a double-pole; double-throw switch to change from talking to receiving. The antenna are strung upon the towers at two of the stations, while the Caribou antenna is stretched across the canyon about forty feet from the high-voltage wires. Here, a single 7/8-in. steel core aluminum cable 930 feet in length is used, tapped at the center, giving a "T" type aerial. The wire used is the same as used on the tower circuits.

The carrier-current system has several features which undoubtedly will be of interest to the operating power men. First, it is a good detector of poor switch contacts, as the minute a switch is closed a click can be heard on the loud speakers indicating that the switch is closed, and should the contacts continue to arc, a hissing or howling noise will immediately be set up in the loud speakers. In this way, faulty switch contacts have been located and taken out of service before any trouble occurred. In fact, the equipment is so sensitive that at the Dispatcher's office slight inconvenience was experienced for several days from a hissing sound in the loud speaker. This sound was not present at the other stations and it was finally located. A potential fuse on a 60-kv. potential transformer in the station adjoining the Dispatcher's office was partially blown and the current actually jumping a small gap, this arcing causing the disturbance on the receiving equipment.

Arcing grounds on the secondary systems can be instantly detected though they are often hard to locate. Grounds on the 4-kv. system fed through two banks of transformers and the bank of transformers connecting to the 100-kv. system located 80 miles from one of our receiving sets, have been noticed and finally located. The high-frequency notes are readily detected, yet no normal frequency hum is noticeable in the receiving sets.

From present experience it would seem that this form of high-frequency communication as applied to the power line circuits, is a valuable addition to the communication system. I do not believe that it will in general replace wire lines on long high-voltage systems that necessarily cover considerable territory where public telephone communication would not be accessible for patrolmen or repair crews on maintenance work, but it is of great value in giving a reliable communication channel to the outlying stations for dispatching work, and in most cases can be utilized without very large expenditures for installation or maintenance.

This system is operating on a wave length of 5500 meters. This particular wave length was selected after careful test, as giving about the best transmission and was of suitable length so as to avoid most outside telegraph interference, this placing the station just between two of the high-powered government telegraph stations. The transmission lines make a good antenna for the longer wave lengths—3000 to 20,000 meters, but a very poor one for wave lengths as covered by the amateur or broad casting range.

The amateur operators seem to experience very little interference from our system as now operated. Only when they are situated close to the transmission lines have they reported receiving our signals, and then only at times when other radio stations were not operating. This interference has been greatly reduced by the elimination of accidental harmonics which were present during the experimental stage.

All experimental work and arrangement of equipment in connection with this system was designed and the installation directed by Dr. Leonard F. Fuller.

ELECTRICAL CONDUCTIVITY OF REFRACTORIES

In the general study of the electrical conductivity of refractories, being conducted by the Department of the Interior at the Columbus, Ohio, experiment station of the Bureau of Mines, tests have been completed on Maryland, Indian and Italian talcs from 500 deg. cent. to and including 1000 deg. cent. These talcs at the present time are being used for the manufacture of electrical insulators and cores for electrical heating appliances. Since 1000 deg. cent. represents the maximum temperature at which these talcs are burned and used, tests were not carried to a higher temperature. Preliminary tests have been made on diaspore and magnesite.

RADIO INSTRUMENTS AND MEASUREMENTS

The Bureau of Standards issued in March 1918 its Circular No. 74, entitled "Radio Instruments and Measurements." The demand for this circular has been such as to warrant the preparation of a revised edition, work on which is at present under way. Owing to the rapid growth of radio communication the appliances and methods used have undergone frequent and radical changes. In this growth progress has been made largely through new inventions and applications and comparatively little attention has been paid to the refinements of measurement. This circular contains information on the more important instruments and measurements actually used in radio work. Many of the subjects with which this circular deals are, or have been, under investigation in the Bureau's laboratories and are not covered in existing publications. No attempt has been made to deal with the operation of apparatus in sending and receiving. A number of corrections and revisions have been made in the present edition and the bibliography of radio publications has been considerably extended. This publication is not yet ready for distribution.

Certain Factors Affecting Telegraph Speed

BY H. NYQUIST

American Telephone & Telegraph Co., New York, N. Y.

***Review of the Subject.**—In considering methods for increasing the speed of telegraph circuits, the engineer is confronted by the problem of transmitting over a circuit the maximum amount of intelligence using a given frequency range, without causing undue interference, either in the circuit being considered or from that circuit to other circuits.*

In this paper the following two fundamentally important factors in connection with this problem are given principal attention:

1. Signal shaping, i. e., giving signals the best wave shape before impressing them on the transmitting medium so as to be able to send signal elements at maximum speed without undue interference into other circuits.

2. Choice of codes so as to transmit the maximum amount of intelligence with a given number of signal elements.

These factors are discussed with the idea of indicating the best methods, as well as to give an idea of what may be expected from these methods.

In connection with the choice of codes, consideration is given to the effect of codes differing in the number of "current values" employed. By this is meant the number of different current values which are employed in a system in forming the different characters. To illustrate, an ordinary land line telegraph circuit makes use of two current values—that is, zero current and the current which flows when the battery is connected to the circuit, or it may use a current value in one direction when battery is connected to the circuit with one polarity and a second current value in the opposite direction of similar magnitude when the battery is connected to the circuit with the opposite polarity. Submarine cables, on the other hand, ordinarily employ three different current values, that is, a definite value in one direction, a similar value in the opposite direction, and zero current. If a quadruplex circuit is analyzed, it will be seen that there are four different current values employed. There is, of course, no theoretical limit to the number of current values which may be thus employed.

The paper also contains a discussion of certain telegraph systems which have been advocated, [1] *and an endeavor is made to clear up various misconceptions relative to the possibilities of these systems*

Signal Shaping

SEVERAL different wave shapes will be assumed and comparison will be made between them as to:

1. Excellence of signals delivered at the distant end of the circuit, and
2. Interfering properties of the signals.

Consideration will first be given to the case where direct-current impulses are transmitted over a distortionless line, using a limited range of frequencies. Transmission over radio and carrier circuits will next be considered. It will be shown that these cases are closely related to the preceding one because of the fact that the transmitting medium in the case of either radio or carrier circuits closely approximates a distortionless line. Telegraphy over ordinary land lines employing direct currents will next be considered. This will be followed by a consideration of the more complicated case of transmission over long submarine cables.

It will be shown that the waves produced by sending rectangular signal elements through suitable electrical networks which round them off before they are impressed on the transmitting medium are probably best in most cases. Comparison will be made between waves shaped by sending rectangular signal elements through suitable networks and waves made up of half cycles of a sine wave, bringing out the inferiority of the latter.

Direct-Current Telegraph Transmission Over a Distortionless Line

Before proceeding with this discussion two terms, which will be used in this paper, and which are considered to be of fundamental importance, will be defined—"signal element" and "line speed." It is usually possible, especially when sending is done mechanically, to divide the time into short intervals of approximately *equal* duration, such that each is characterized by a definite, not necessarily constant, voltage impressed at the sending end. The part of the signal which occupies one such unit of time will be called a "signal element." For example, the letter *a* in ordinary land telegraphy will be said to be made up of five signal elements, the first constituting a dot, the second a space and the next three a dash. The "line speed," as used in this paper, equals the number of signal elements per second divided by two. In ordinary land telegraphy the line speed is equal to the dot frequency when a series of dots separated by unit spaces is transmitted.

The discussion will first be limited to the case of direct-current telegraphy over a distortionless line. This case is the simplest and in addition the results will aid in understanding the more complex cases. It may aid in obtaining an understanding of this case to assume that the distortionless line is made up simply of series and shunt resistances.

A distortionless line, such as the one which has been assumed, will transmit all frequencies with equal efficiency from zero upward. In considering applying direct-current telegraph to this line, it will be assumed

1. A. C. Crehore and G. O. Squier. "A Practical Transmitter Using the Sine Wave for Cable Telegraphy; and Measurements with Alternating Currents upon an Atlantic Cable." A. I. E. E. Trans., Vol. XVII, 1900, p. 385.

G. O. Squier. "On An Unbroken Alternating Current for Cable Telegraphy." *Proc. Phys. Soc.*, Vol. XXVII, p. 540.

G. O. Squier. "A Method of Transmitting the Telegraph Alphabet Applicable for Radio, Land Lines, and Submarine Cables." *Franklin Inst., Jl.*, Vol. 195, May 1923, p. 633.

Abridgement of paper to be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924. ***Complete copies available to members upon request.***

that the telegraph circuit will have assigned to it only a limited range of frequencies from zero upward, the remaining frequency range being assigned to some other uses, such as ordinary telephone and carrier telephone and telegraph. It will also be assumed that the direct-current telegraph circuit is worked at as high a speed as the frequency range assigned to it will permit.

A number of different wave forms which might be employed to make up the telegraph signal elements will next be examined, consideration being given first to the waves which will be received at the distant end when the different wave forms are impressed at the transmitting end and second to the interference which will be produced in the higher range of frequencies which has been assigned to other uses.

Three forms of voltage waves which will be considered are shown in Fig. 1. *A* in that figure shows the simplest form of voltage wave, namely, the rectangular form which is produced by applying a battery for a given interval of time and then substituting a short circuit for it. *C* in the figure is the wave produced by transmitting the rectangular voltage wave *A* through an electrical network which is the one indicated by the

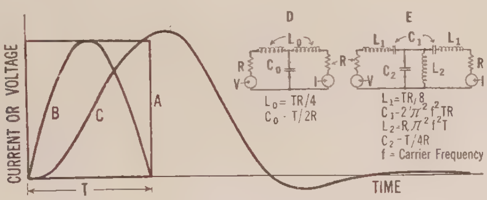


FIG. 1

A - Rectangular Voltage Wave
B - Half Cycle of Sinusoidal Voltage Wave
C - Rectangular Voltage Wave Modified by Being Passed through Network Shown at *D* or *E*.

letter *D* in the figure. (Other forms of networks might also be selected which would produce similar results.) *B* in the figure is a wave which has the shape of a half cycle of a sine wave. In what follows this wave will be referred to as the "half-cycle sine wave."

In considering the waves which will be received when the above waves are applied at the transmitting end, use will be made of the following general principles, which have been stated by Malcolm[2], for the case of a submarine cable circuit and discussed for the general case in Appendix *A*.*

When a telegraph circuit is worked at a line speed as high as will be permitted by the available frequency range, the shape of the received signal will be practically independent of the shape of the transmitted signal, and further, the magnitude of the received signal will be approximately directly proportional to the area included within the impressed voltage wave.

The area included within the impressed voltage wave being of principal importance so far as the wave received at the distant end is concerned, the areas under the three voltage waves shown in Fig. 1 will next be examined. The areas under waves *A* and *C* will be found to be substantially equal while the area under the wave *B* is only about 0.6 as great. Consequently, it should be expected that waves *A* and *C* will be about equally good from the standpoint of the received signals, while wave *B* will be poorer, producing received signals only about 0.6 as great in magnitude. If the maximum voltage (or power) impressed at the sending end is limited to some given value, the rectangular wave is seen to be the optimum, since this wave has the maximum area. While the area shown under curve *C* is approximately equal to that under the rectangular wave, the effect produced when a number of signal elements of the same polarity and magnitude are sent in succession is such that the maximum voltage transmitted will exceed slightly the corresponding voltage for the case of the unmodified rectangular wave due to overlapping of adjacent signal elements.

The above comparison of the three waves of Fig. 1 from the standpoint of received signals holds not only for signal elements, but also for complex waves comprising a number of elements. Since for the speeds under consideration the received currents for different shapes of signals applied at the sending end are substantially of the same form, differing, at most, in magnitude, it follows from the principle of superposition that any complex signal, whether built up of elements of one shape or another at the sending end, will produce substantially the same wave form at the receiving end, the differences in the shapes of the elements at the sending end producing differences principally in magnitude of the received waves.

Consideration will next be given to the relative interference which the different wave forms of Fig. 1 will produce in the frequency range assigned to other circuits. Since interference into other circuits results from having the telegraph signal elements contain frequencies which spread into the ranges assigned to other circuits, it is evident that the wave will be the best from the standpoint of interferences which contains the least amount of these outside frequencies. By making use of a method which is discussed in Appendix C, the frequency components of the three waves illustrated in Fig. 1 have been computed and are shown in Fig. 2. The frequency marked 1/2 *T* in the drawing equals the line speed. *T* in this connection has the same value as in Fig. 1. The letters in this figure refer to the corresponding waves in Fig. 1, *A* being the components of an isolated rectangular wave, *B* the corresponding components for the half-cycle sine wave, and *C* those for the rectangular wave after it has been transmitted through the network *D* in Fig. 1. It is seen from Fig. 2 that the rectangular wave form *A* contains the greatest amount of currents of higher frequencies and is, therefore, the poorest from the standpoint of interference. The half-cycle sine wave contains less of these

2. H. W. Malcolm. "Theory of the Submarine Telegraph and Telephone Cable." The Electrician Printing & Publishing Co., London, March 1917.

*For appendixes see complete papers.

higher frequencies although, as will be seen, the high-frequency components are far from negligible. The wave C is the best from the standpoint of interference, since it contains the least amount of these higher frequencies.

From the preceding it is concluded that for the case under consideration, the wave form C in Fig. 1 produced by sending a rectangular shaped signal element through a suitable network is the most suitable. This wave form is almost the optimum from the standpoint of the received signals while from the standpoint of interference into other circuits it leaves little to be desired.

Carrier and Radio

The results for the distortionless line are particularly applicable to the cases of radio and carrier telegraphy because in these cases we have a transmitting medium which is substantially distortionless. We may again make use of Fig. 1 to illustrate three possible voltages, it being understood that these curves represent

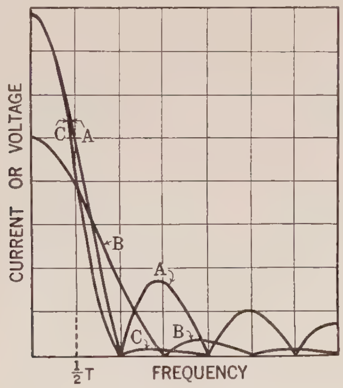


Fig. 2

A - Frequency Components of a Single Dot, Rectangular Wave
B - Frequency Components of a Single Half Cycle of a Sine Wave
C - Frequency Components of a Single Dot, Rectangular Wave Passed through Network Shown in Fig. 1

the envelope or outline of the transmitted currents which are in reality of a frequency considerably higher than the signaling frequency. If now we limit consideration to the case where the carrier frequency is located in the middle of the transmitted frequency band, then, this case becomes very similar to the direct-current case and what has been said about the received wave shape being independent of the transmitted one and its magnitude being directly proportional to the area under the transmitted voltage curve still holds. One important difference is that, whereas in the direct-current case the network shown at D, Fig. 1, is used in the alternating-current case having the carrier located in the middle of the free transmitted range, the network shown at E, Fig. 1, is used. A further difference is that in the case of radio where very high frequencies are involved, it may not be practicable to construct the required networks. In that case, however, it is practicable to produce the corresponding direct-current wave and utilize it to modulate the radio wave.

What was said about interference from the circuit in question into other circuits in the direct-current case above also holds for the case of radio and carrier with the difference that whereas Fig. 2 shows a band of frequencies extending from zero up, the corresponding curve in the case of radio and carrier consists of two such bands. The complete curve for radio and carrier is substantially symmetrical with respect to the ordinate corresponding to the carrier frequency, and the right-hand portion is similar to the curve shown in Fig. 2. It will be obvious that the rectangular wave and the half-cycle sine wave are both objectionable, as voltage waves to be applied to the transmitting medium, because they contain frequency components which may easily extend into the range allotted to neighboring carrier bands. For this reason it is customary in carrier telegraph practise to make use of a transmitting filter to cut off these interfering frequencies. The voltage impressed on this filter is substantially rectangular in outline but after passing the filter it has a shape which is approximately similar to curve C in Fig. 1, and which, therefore, produces less interference than a half-cycle sine wave.

Land Lines

The case of land lines is somewhat different from the case discussed previously because it is not economically desirable to utilize the full frequency range available. In other words, the great expenditure for terminal apparatus that may be proper in the case of submarine cables and long distance radio circuits is not warranted. In land circuits the highest frequencies transmitted are considerably greater than the required line speed. When this is the case, it is usually possible and desirable to make use of the available range to increase the steepness of the received wave. A steep wave front results in prompt operation of the receiving relay and this in turn results in minimum distortion. If a half-cycle sine wave were to be employed instead of the usual rectangular wave or if a network were to be employed which were to round off the wave to the extent indicated in Fig. 1, the received wave would necessarily lose a great part of its steepness and as a consequence the response of the receiving relay would be less positive and the signals would be distorted. It will of course be understood that by means of suitably proportioned networks the wave can be rounded just enough to meet the interference requirement, still retaining sufficient steepness to insure prompt operation of the receiving relay. Therefore, rounding by means of networks is preferable.

If it should be desirable and practicable to utilize the frequency range to its fullest, what has been said above about a distortionless line holds without any substantial modification and it would, in that case also, be more advantageous to use a wave rounded by means of suitable networks than to impress on the line a wave of the half-cycle sine form.

Submarine Cables

In the case of submarine-cable telegraphy, there is a limitation on voltage which has not been emphasized in the simple direct-current case discussed above. The voltage which may be impressed on the cable is limited to a definite value. Moreover, for certain reasons, the cable has an impedance associated with it at the sending end which may make the voltage on the cable differ from the voltage applied to the sending-end apparatus. Inasmuch as the limitation in this case is voltage limitation at the cable, the ideal wave is one which applies a rectangular wave to the cable rather than to the apparatus, because it insures that the area under the curve should be the maximum consistent with the imposed limitations. It would be possible to make the transmitting-end impedance approximately proportional to the cable impedance throughout most of the important range. This would insure that the wave applied to the cable would have approximately the same shape as the wave applied to the apparatus. It would probably be desirable for practical reasons to make this impedance infinite for direct current.

In connection with the submarine cable a special kind of interference is particularly important, namely, that due to imperfect duplex balance. For a given degree of unbalance, the interference due to this source may be reduced by putting networks either in the path of the outgoing current or in the path of the incoming current. These facts, together with the frequency distributions deduced above for each of the several impressed waves as exhibited in Fig. 2, make it apparent that the beneficial reaction on the effect of duplex unbalance, which can be obtained by the use of a half-cycle sine wave instead of a rectangular wave, can be obtained more effectively by the use of a simple network, either in the path of the outgoing or in the path of the incoming currents. Either of these locations is equally effective in reducing interferences from duplex unbalance, but the location of the network in the path of the outgoing current has the advantage that it decreases the interference into other circuits, whereas the location in the path of the incoming current has the effect of reducing the interference from other circuits.

Before leaving the matter of submarine telegraphy, it may be well to point out that it is common in practise to shorten the period during which the battery is applied so as to make it less than the total period allotted to the signal element in question. For instance, if it is desired to transmit an *e* the battery may be applied for, say, 75 per cent of the time allotted to that *e* and during the remaining 25 per cent the circuit is grounded. The resulting voltage is shown in Fig. 3F. From the foregoing, it is concluded that this method is less advantageous than the application of the voltage for the whole period, because while the shape of the received signal is substantially the same in the two cases, the magnitude, being proportional to the area under the voltage curve, will be less. A cursory examination of the literature does not disclose that anything has been published on the experimental side either to confirm or to oppose this result.

Choice of Codes

A formula will first be derived by means of which the speed of transmitting intelligence, using codes employing different numbers of current values, can be compared for a given line speed, *i. e.*, rate of sending of signal elements. Using this formula, it will then be shown that if the line speed can be kept constant and the number of current values increased, the rate of transmission of intelligence can be materially increased.

Comparison will then be made between the theoretical possibilities indicated by the formula and the results obtained by various codes in common use, including the Continental and American Morse codes as applied to land lines, radio and carrier circuits, and the Continental Morse code as applied to submarine cables. It will be shown that the Continental and American Morse codes applied to circuits using two current values are materially slower than the code which it is theoretically possible to obtain because of the fact that these codes are arranged so as to be readily deciphered by the ear. On the other hand, the Continental Morse code, as applied to submarine cables, or other circuits where three current values are employed, will be shown to produce results substantially on par with the ideal. Taking the above factors into account, it will be shown that if a given telegraph circuit using Continental Morse code with two current values were rearranged so as to make possible the use of a code employing three current values, it would be possible to transmit over the rearranged circuit about 2.2 times as much intelligence with a given number of signal elements.

It will then be pointed out why it is not feasible on all telegraph circuits to replace the codes employing two current values with others employing more than two current values, so as to increase the rate of transmitting intelligence. The circuits, for which the possibilities of thus securing increases in speed appear greatest, are pointed out, as well as those for which the possibilities appear least.

Theoretical Possibilities Using Codes with Different Numbers of Current Values

The speed at which intelligence can be transmitted over a telegraph circuit with a given line speed, *i. e.*, a given rate of sending of signal elements, may be determined approximately by the following formula, the derivation of which is given in Appendix *B*.

$$W = K \log m$$

Where W is the speed of transmission of intelligence,
m is the number of current values,
and, K is a constant.

By the speed of transmission of intelligence is meant the number of characters, representing different letters, figures, etc., which can be transmitted in a given

length of time assuming that the circuit transmits a given number of signal elements per unit time.

Substituting numerical values in this formula gives the following table which indicates the possibilities of speeding up the transmission of intelligence by increasing the number of current values.

Number of Current Values Employed	Relative Amount of Intelligence which can be Transmitted with a Given Number of Signal Elements
2	100
3	158
4	200
5	230
8	300
16	400

This table indicates that there is considerable advantage to be secured in going to more than two current values where the circuits are such as to permit it and where the line speed is not lowered as a result. The limitations will be outlined below. It should also be noted that whereas there is considerable advantage in a moderate increase in the number of current values, there is little advantage in going to a large number.

Codes Now in Common Use—Comparison with Ideal

In the case of printer codes, the theoretical results derived correspond closely to practise, as will be obvious from the method of deriving the formula.

In order to compare the theoretical possibilities indicated by the formula with the results which are obtained when non-printer codes are constructed, several codes were assumed, and for each one the number of signal elements required to produce an average letter was deduced. The method of doing this is set forth in Appendix *D*. This work resulted in the following table:

	Signal Elements per Letter	Relative Number of Letters for a Given Number Signal Elements
American Morse (two current values)	8.26	74
Continental Morse (two current values)	8.45	73
Ideal (two current values)	6.14	100
Continental Morse (three current values)	3.77	163
Ideal (three current values)	3.63	169

The column in the above table headed "Relative Number of Letters for a Given Number of Signal Elements" makes possible direct comparison with the results predicted from the formula as given in the table which preceded. It will be noted that the ideal three-current-value code gives an increase in the number of etters for a given number of signal elements as compared with the ideal two-current-value code which is in fair agreement with the theoretical ratio of 1.58:1. It will also be noted that the Continental three-current-value code which is actually in use in the case of submarine cables appears to come quite close to the ideal. In the case of the Continental and American Morse codes, however, where only two current values are used, the results fall short of the ideal, the ratio between the results actually obtained and the ideal being approximately 1.4:1. The reason for this is that a certain proportion of the possible speed is sacrificed in order to make it possible to read the signals by means of a sounder instead of recording them. For instance, the dash has been assumed to be approximately three times as long as the dot. If the signals were mechanically formed at the sending end and recorded at the receiving end, it would be possible to make use of markings 1, 2, 3, etc. signal elements long, as well as corresponding spacings. The ideal codes were so constructed.

It will be seen that the figures deduced for the Continental Morse and the American Morse are substantially identical for two current values. This result probably does not correspond with practise; it is thought that the difference in speed between these two codes is considerably greater, say on the order of 10 or 15 per cent in favor of the American Morse. The discrepancy is due partly to the fact that no account has been taken of figures and punctuation marks in the present computations and partly to the fact that the assumptions as to relative lengths of space is not strictly in accordance with practise.

From the foregoing, it is seen that there is a two-fold gain in changing from the two-current-value American or Continental Morse codes to the three-current-value Continental code. In the first place, there is a theoretical increase in the ratio of 1.6:1 which accompanies the change from the two-current-value to the three-current-value code. In the second place, there is an incidental increase in the ratio of 1.4:1, due to the fact that the present two-current-value codes are longer than would be necessary, if receiving were done by means other than the ear. The total increase in going from the two-current-value Continental or American Morse codes to the three-current-value Continental code is, therefore, in the ratio of $1.6 \times 1.4:1$ or 2.2:1, provided the line speed is the same. In this connection it should be noted that in the case of the American Morse, the ratio is probably somewhat less than this for the reasons pointed out above.

Limitations in Applying Codes with More than Two Current Values

Certain inherent limitations which have to do with how much the number of current values can be advantageously increased are as follows:

1. Fluctuations in transmission efficiency of the circuit,
2. Interference,

3. Limitations on the power or voltage which it is permissible to employ.

In addition it may be stated that, in general, whenever more than two current values are employed it is necessary to make the sending and receiving means more complicated and expensive. There may be nothing to gain, therefore, in using codes other than those made up of two current values where the telegraph circuits are cheap.

Considering now the features which limit the number of current values which can be employed, it is believed that the importance of the first factor will be obvious. If the line is subject to fluctuations so that the stronger currents at certain times become less in magnitude than the weaker currents at other times, it will be impossible to discriminate between the different current strengths making up the code, particularly if the fluctuations are rapid.

In connection with interfering currents, it is evident that these may be of such polarity as to add to or subtract from the signaling currents and it is consequently necessary to separate the various current values employed sufficiently so that one current value with the interference added may be distinguished from the next larger current value with the interference subtracted.

The spacing between the current values being determined by the interference and fluctuations in transmission efficiency, it will be seen that the maximum number of current values which can be employed is determined by the maximum power which it is permissible to use.

In the case of land line telegraph circuits operated with direct currents, it is well known that quadruplex circuits are much more seriously affected by fluctuations and interference than are circuits employing only two current values. (A quadruplex telegraph circuit employs four current values for transmission in one direction). In general, it may be said that the possibilities of improving ordinary direct-current operated telegraph circuits in this manner do not appear particularly promising.

In the case of wireless transmission over great distances all three of the above factors are important in limiting the number of current values which can be effectively employed. In the first place, as is well known, large variations take place in the efficiency of the transmitting medium so that the received signals vary considerably in magnitude from time to time. Secondly, the interference, at least at certain seasons, is great enough to make it difficult to distinguish between the current values even when the usual method which employs only two current values is employed. Thirdly, the received power is limited because of the great attenuation suffered by the wireless waves.

In the case of carrier transmission, it may be that there will be a field for the use of more than two current values. The relative cheapness of the line circuits, however, will tend to limit the amount by which it will be economical to increase the cost and complexity of the receiving apparatus. Moreover, it should be borne in mind that no allowance has been made for the effect on the line speed of increasing the number of current values, this being considered outside the scope of the present paper.

Changing an existing network of telegraph circuits so as to employ a code with three instead of two current values would require new types of telegraph repeaters as well as new sending and receiving apparatus, and new operating methods. It is considered to be outside of the scope of this paper to go into a discussion of the details of this matter.

"Sine Wave" Systems

Considerable interest and discussion has been created by suggestions which have been made to use so-called "sine wave" systems of telegraphy. In view of this, a brief discussion of these systems is given below.

A brief analysis of what are the fundamental features of these systems will be given and, based on the results which have been developed in the preceding discussion, comparison will be made of these systems with systems based on other principles. A particular effort will be made to clear up what appears to be fundamentally incorrect assumptions which underlie the arguments which have been advanced in favor of these "sine wave" systems.

Crehore-Squier System. The use of a sine wave envelope to improve the characteristics of telegraph signals was advocated by Crehore and Squier.[3] The words "United States" formed by means of a wave of this type are shown in Fig. 3*d*. The code employed is the same as the ordinary Continental Morse, the only difference being that the signal elements consist of half-cycle sine waves.

In what has preceded, it has been shown that a half-cycle sine wave has a smaller area than a rectangular wave rounded off by passing through an electrical network and, consequently, the sine wave is inferior to the latter from the standpoint of the received signals. From the standpoint of interference into other circuits, it has also been pointed out that the half-cycle sine waves contain more high-frequency components than properly rounded off rectangular waves. Consequently more interference into other circuits will be produced with the wave made up of signal elements consisting of half-cycle sine waves.

Squier System Applied to Submarine Cables. A more recent suggestion by Squier[4] gives the wave shown in Fig. 3*a*. This wave resembles the one advocated by Crehore and Squier in that each signal element consists of a half-cycle sine wave. As has been pointed out, there is no advantage gained by this.

The difference between the two systems lies in the fact that the wave in Fig. 3*a* uses three absolute values and crosses the axis once every half cycle. The code is the same as the Continental, a space being indicated

3. Crehore and Squier, loc. cit.
4. Squier, loc. cit. *Proc. Phys. Soc.*

by a half-cycle sine wave of one unit amplitude, a dot by a half-cycle sine wave of two units amplitude and a dash by a half-cycle sine wave of three units amplitude.

By referring to the figure, it will be seen that the resulting wave resembles a continuous sine wave, except for the fact that successive half cycles differ in magnitude. For this reason, the code may be termed an "unbroken-reversals" code.

In considering the application of this code to submarine cable telegraphy, it is convenient to make use of an analysis which is carried out in Fig. 3. Fig. 3*a* shows the words "United States" written in the code advocated by Squier. Fig. 3*b* shows a constant sine wave whose amplitude is equal to the amplitude of a dot in Fig. 3*a*. Fig. 3*c* shows the result obtained by subtracting the wave of Fig. 3*b* from the wave of Fig. 3*a*. On comparing this last wave with the wave shown in Fig. 3*d*, it will be seen that the two waves are electrically equivalent. They differ only in having the signal elements permuted.

It is thus evident that the wave shown in Fig. 3*a* is

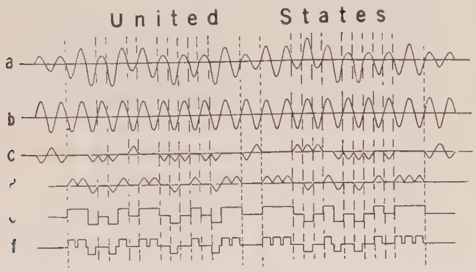


Fig. 3

a - Unbroken reversals code (space = 1 unit, dot = 2 units, dash = 3 units)
b - Constant sine wave, 2 units
c - Wave resulting when substracting *b* from *a*
d - Sine Wave code; note similarity between c and *d*
e - Rectangular wave, unmodified
f - Rectangular wave, modified by grounding apex one fourth of the marking time in addition to the spacing time

made up of two components; one being the inert component shown in Fig. 3*b* which transmits no intelligence, and the other the intelligence carrying component illustrated in Fig. 3*c*.

The fact that the component shown in Fig. 3*b* does not carry intelligence from the sending station to the receiving station is made clear when we consider that its value at any moment is predictable and that the component can in fact be produced locally.

The net effect of this component is to reduce the voltage available for intelligence transmission to one-third of the total voltage. For example, if it is permissible to apply 60 volts to a particular cable, 40 volts out of these would be used up in transmitting the inert alternating-current wave and only the remaining 20 volts would be useful for the transmission of intelligence.

Radio and Carrier Telegraphy. Squier has also advocated[5] that the combination of sine wave envelopes, unbroken reversals and a three-current-value code be applied to radio and carrier telegraphy.

The advantages and limitations in applying codes with more than two current values have been fully discussed above, and do not need to be gone into further here. It will be evident that the combining with these of sine wave envelopes and unbroken reversals does no good.

The matter of using sine wave envelopes was discussed above, the discussion pointing out that waves with sine-wave envelopes are inferior to waves produced by sending rectangular shaped signals through suitable networks, both from the standpoint of the received signals, and from the standpoint of interference into other circuits.

The "unbroken reversals" bring in again the use of an inert component. Due to the fundamental difference between cable telegraphy on the one hand, and radio and carrier as usually practised on the other, the inert component in the latter case is somewhat smaller than in the former. In the code advocated by Squier, the current which may be subtracted without greatly affecting the intelligence-carrying capacity of the signals, is about one unit in value, which is the current corresponding to a space. When this current has been subtracted, the space current is reduced from one unit to zero, the dot current from two units to one, and the dash current from three units to two. This subtraction having been carried out, it is seen that the maximum intelligence-carrying component is approximately two-thirds of the maximum current actually employed. (This figure of two-thirds compares with the figure of one-third for the submarine cable.)

In the case of radio, the amount of power which must be radiated from the transmitting station is of particular importance. Since with the system advocated by Squier about two-thirds of the maximum voltage which is radiated is effective in transmitting intelligence, it is evident that about twice as much power must be radiated as would be required if the inert component were not transmitted.

Incorrect Assumptions. Two incorrect assumptions are made in the papers referred to and underlie a considerable portion of the arguments advanced in favor of the systems advocated by Squier.

One of these is that a wave, whose elements are half-cycle sine waves, lends itself to tuning. It is true that in the case of the "unbroken-reversals" code a certain amount of tuning can be secured, but this tuning applies only to the inert unvarying component in the wave, which carries no intelligence. The fact, shown in Fig. 2, that the intelligence-carrying component contains no outstanding narrow range of frequencies to which tuning can be applied should make obvious the error in this assumption.

The other assumption is that a wave, which is ideal for the transmission of power, is also ideal for the transmission of intelligence. As a matter of fact, the transmission of intelligence inherently involves rapid and unpredictable changes in the current, whereas the transmission of power is best brought about by steady current, either direct or alternating. These two conditions are, of course, incompatible.

5. Squier, loc. cit., *Franklin Inst., Jl.*

Engineering Literature

A Critical Review of the Tendencies in Technical Literature, with a Statement of Some of the Problems of Publication

BY DONALD Mc NICOL
Fellow, A. I. E. E.
Chairman Publication Committee

IN a recent broad discussion of the problems of engineering colleges, Gano Dunn, past president of the Institute, speaking of the training which should be given students, said: "Ground them thoroughly in the English language, a lack of command of which in writing and speaking is the greatest single defect in the college training of most engineers. It is not enough for an engineer to be skilled; he must make his skill prevail, and the power and culture that come from familiarity with English are tremendous forces in the success of an engineer."

To this might be added the thought that there is no writer of engineering literature who has not gained handsomely from his faculty of writing. The ability to write aids largely in the task of getting the most out of the writings of others. Through reading the student becomes a scholar.

Physicists and engineers engrossed in the task of furthering scientific progress, or of applying the fruits of science to modern commercial advancement may well pause for a moment to inquire into the growth of technical literature; the tendencies of this literature, beneficial and of no benefit, and with a view to the utilization of new forms of literary expression and new ideas of publication, if such have come into successful use in other activities and would be applicable to the reporting of engineering progress.

A good carpenter looks to his tools. The china merchant must have for sale not only good china, but must have dependable crates to carry the china to its destination. The best of agricultural products may rot in the fields if there is not available a vehicle by means of which these may be moved to market. Vehicles of thought are the written and the spoken word.

The good carpenter, upon occasion, ceases building while he takes stock of his tools; sharpening, cleaning, replacing or discarding where advisable.

Science is a product peculiarly dependent upon a vehicle to carry it forward. Except in rare instances forward steps in science have been of minute measure, and the vehicle is the literature in which is recorded the discoveries of physicists, research engineers and inventors.

Publishers of technical literature are at all times confronted with a variety of problems more or less pressing. This applies to the publishers of commercial periodicals as well as to engineering societies whose periodical journals are the main points of contact with large memberships.

In what follows it is my intention to present only some views and impressions which have come to me on the general subject of engineering literature during the past few years while it has been my privilege to be in close touch with the publication problems of the Institute.

Practically all we know about electricity and electrical engineering is a matter of records which constitute the existing literature of the science. All that engineering students learn about electrical engineering in the years immediately ahead is now available in text books, technical journals, papers or transactions, or will be written and so recorded in the interim.

The responsibility, therefore, which rests upon those who will prepare the lessons—do the writing—is one which devolves proportionately upon those called consecutively to direct engineering thought and engineering works, whether as managers of industrial organizations, officers of technical societies, teachers in engineering schools, editors, or as directors of research.

Style in Writing

Writers of engineering literature are situated favorably to contribute measureably toward stemming the growing misuse of English in this country. Engineer writers deal with topics which may be made clear to readers only by the employment of exact phraseology. The supreme quality of a language is precision of meaning, each word having a definite and unmistakable significance.

An observing editor has said that "The simplest way to popularize science is to record results only. To popularize the processes whereby the results are obtained, to explain the underlying theory of the processes in language that a technically uninformed person can understand, requires not only real scientific knowledge, but a gift of presentation with which few are endowed."

To this view most editors will subscribe without reservation, but it is possible that the engineering societies with large memberships have here an overlooked opportunity of educational value. Is it not possible that thought given to the training of engineer writers would in time relieve the demands upon gift and endowment?

An outstanding and ever present problem before the

publishers of the larger technical and trade journals is to induce subscribers to read the periodicals—to do more than glance hurriedly at headlines. It is possible that should wider reading of technical journals be brought about that this would follow the discovery that stories containing data, descriptions of works and operations, and details of construction may be presented in sentences embodying the beauty as well as the utility of the language.

I have in mind a comparatively recent technical book which had an unusually large sale and in which the author followed a style so attractive that the reader was inveigled into romping through the pages as in his youth he devoured page after page of Nick Carter. In one spot the author, with a view to impressing upon the student the necessity for thoroughness plus speed in effecting an operation, launches the point with the quotation: "If t'were done when t'is done t'were well t'were done quickly."

So far technical literature has been able to accomodate without contamination only one book in perhaps one thousand employing a style of this order. Yet, the venture from the publisher's viewpoint usually is quite a success.

Books employing pioneering styles which have found their way into good society on bookshelves include Faraday's "Chemical History of a Candle" and John Mills' "Letters of a Radio Engineer to His Son."

The intensely practical age through which we are passing has been served by a long line of "How to do it" books which publishers have favored because of the demand—the ready market. The "How to do it" book is not always a good presentation of engineering principles nor is the literary product always a credit. The sales success of this type of book is a symptom—an index of haste to attain quick results. The writers of such books aim to interpret science for those who unavoidably or avoidably missed engineering education, and for those who would take all possible short cuts to an average working familiarity with scientific knowledge.

This would perhaps be an unobjectionable tendency in learning if the students of these books constituted a class comparable in objective with the dilettante in art, but often in industry we find in the draughting room and the test room graduates of the "How to do it" books—and schools of the same order—because none other is available.

It may be that in an age of inventions the practical arts, under pressure of economic demands, perforce lead the literature. But, should the forward steps in science become smaller and inventions less revolutionary in character stimulation might be accelerated by the existence of more complete and higher forms of engineering literature than those created under stress such as that experienced during the past three decades.

In time to come should real advance appear at a standstill it is possible we may have engineering works resembling in purpose literary productions such as "Vanity Fair" and "Uncle Tom's Cabin."

In setting up a perspective it is well to remember that literature as a tool, as a means toward an end is a worthy subject for consideration by forward-looking engineers.

Rules and theories in writing are the Chinese Walls of the brain. Must we say that technical writing is excepted: That technical stories may be written only in a certain definite style, uniform, prosaic, dry, and without prosody or human interest?

Since the days of Portia, and before, words have been the tools of the lawyer. With words the advocate constructs mental pictures designed to impress the listener sympathetically toward a definite idea.

In agriculture we have the dirt farmer and the book farmer. Each prides himself upon his classification, but rapidly the two classes are fusing. In time, survival will find professional agriculture under the management of a book-dirt generation of farmers. In engineering much the same classifications exist; in the theoretical and the practical engineer. As a wit has said, we have our "stationery" and our "stationary" engineeers.

Rigidity of style in engineering literature gives us volumes of Transactions which we like to think will be a credit to us a hundred years from now, but it is possible that less rigid rules would permit of hastening the day when the practical engineer shall become theoretical and vice versa.

Throughout the pages of engineering literature, now historical, may be found many dignified and solemn statements which, read in the light of subsequent scientific developments, provoke enjoyable chuckles because of the grave and erudite manner employed to set forth hypotheses which in fact were wide of the truth.

It may not be wise to conclude from this that engineering writers should standardize two styles—one to be used to set down indisputable facts, the other for use when presenting ideas which are open to question and which if set down in playful paragraphs would carry the suggestion that the writer wrote "with his tongue in his cheek."

In our country we have cherished the thought that the people as a whole are on familiar terms with advances in science, as a result of the fact that our technical, scientific, and "popular science" periodicals are read by three and one-half million persons. Still, when Dr. Einstein attempted from our rostrums to state a few plain truths in words having definite meaning he was moved to commiserate with us with respect to the average ability of our people to understand things.

There is a vast difference in the audiences of engineers who write technical papers for journals maintaining high standards of engineering probity, and those pioneering spirits who endeavor to supply the science hunger of the layman by giving him stuff

with color, couched in terms which he who runs may read. Out of these extremes may come a style which will be common, embodying modifications and compromises; although it is perhaps well to realize that the ideas of popularizing a knowledge of scientific principles, and popularizing a knowledge of the uses of electric devices, are separate and distinct.

In classical literature the style usually follows the mood of the matter. In engineering literature must the style be the same regardless of the matter? Or must we conclude that in engineering literature the matter always is the same?

Scientific papers, in the lay view, are of a severely didactic nature, employing Babylonish terminology and requiring trained minds to understand them. An engaging rhetoric might bring to these subjects a wider reading, but is that not what the semi-technical journals now present in their diluted science?

In engineering literature the highest development we have of the literature sometimes referred to as didactic are the instruction books issued by the large correspondence schools. These, also definitions, specifications, etc., are set up in the simplest words applicable. Here the utility of the language is employed to the total exclusion of its euphonious possibilities. In these writings there is little need of sugar-coating—the reader almost invariably is under the urge of necessity and has little thought for or expectation of allurement. Indeed, less prosaic rhetoric might fail where the rigid style succeeds—the mood of the instructor is conserved.

The writer occupies the vast domain between the laboratories and the multitude of those who would know. He must reach in and bring forth the discoveries of the physicists; must translate these discoveries into understandable terms, and must, without loss of truth, present his subject to the multitude at opportune moments and under acceptable auspices.

The number of trained scientists is small compared with the multitude who would or should have a knowledge of scientific progress. Is it not important that science should be understood by the multitude? Can the scientist interpret science? Is the number of gifted writers who understand science sufficiently large to interpret science to the multitude? Interpreters have a way of being creatures of occasion.

The masses have their religion supplied to them in song, their history in pageant, and much of their culture in music, picture, sculpture and poetry. The artists are the interpreters.

Sculptors and painters already have tried their skill at interpreting science. They may continue. H. G. Wells, Rudyard Kipling, Camille Flammarion, George Stirling, John Masefield and Samuel Butler each in recent years has sensed an opportunity to interpret science through tales and poems.

Masefield, in a sonnet, says:

> I could not sleep for thinking of the sky,
> The unending sky with all its million suns....
>
> Or, in the one that opens thus, in bio-chemical fashion:
>
> What am I, Life? I think of watery salt
> Held in cohesion by unresting cells.

What of the influence of the broadcast radiophone? What the future will bring in the way of extensions of radio broadcasting may only be guessed at. In the present early tryouts of topics from existing experimental stations it appears that talks on scientific subjects are sufficiently popular to warrant their continuance. In these pioneer days of the radiophone when talks on serious subjects are broadcast it is thought necessary to sandwich these between renditions of popular music, but a time may arrive when the lecturer will have the students of the whole continent as an audience, and in that day manner, style and mood will play the same important parts these factors play on more restricted rostrums.

Should it develop that in broadcasting didactic talks are more successful when the lecturer departs knowingly from sing-song style and from dry text there will be opportunity for a readjustment of ideas related to engineering English. A danger may be that radio lecturers will be inclined to "talk up to" their subjects. It was Aristotle who said that the style should be lowered or raised according to the subject. Further: "Style will possess the quality of being in good taste if it be expressive at once of feeling and character, and in proportion to the subject matter. This proportion, however, is preserved, provided the style be neither careless on questions of dignity, nor dignified on such as are mean; neither to a mean word let ornament be superadded, otherwise it appears mere burlesque."

Growth of Electrical Literature

Electrical literature in the United States dates from the publication in Philadelphia, in 1819, of Tiberius Cavallo's "Elements of Natural and Experimental Philosophy." This work, written during the time that Humphrey Davy, Frances Ronalds, Schweigger, La Place, Arago, Ampere and Oersted were uncovering secrets of all prior time, presented the first complete review of the early discoveries in electricity and magnetism.

"Electricity," a book published by John Farrar, in 1826, was widely read in this country. It was largely a translation of the published writings of J. B. Biot, France, 1816 and 1824.

A third book which had wide reading in America was "Treatises on Electricity and Magnetism and Electro-Magnetism" by P. M. Roget, London, 1832. This work presented an excellent review of the state of the knowledge of electricity at the time Morse was at work on his electromagnetic telegraph.

The first strictly American popular book on Electri-

city was "Davis' Manual of Magnetism" published in Boston in 1842, by Daniel Davis, Jr.

Then followed a succession of books on Telegraphy which served to inspire study and experiment. In 1879 George B. Prescott, New York, wrote a comparatively large book entitled "The Speaking Telephone, Electric Light and Other Electrical Inventions" which work was the forerunner of the long list of books which followed dealing with advances in electric development.

The advent of large corporations had as one result the limiting of the field for independent writers of technical books, due to the fact that electric companies early began the compilation of data applying specifically to their own operations, this material being published in handbooks, instruction books, catalogs, etc., for free distribution to the individual company's employees.

This tendency increased so that as early as the year 1910 it was apparent that the publication of electrical books for general circulation was not by any means keeping pace with the increase in the number of men engaged in electrical pursuits.

During the past twenty years, also, the growth of filing systems wherein may be deposited for quick reference, papers, clippings and reports on classified subjects, has had the effect of making it extremely difficult to write a new book on a technical subject which would be as complete as the information on the same subject stored in the files of engineers directly interested.

Engineering libraries available to the independent student consist mainly of books, and a time has arrived when the bookworm of the libraries has open to him on any specific subject a limited and more or less out of date literature compared with what is available on the same subject in the technical files of corporations and of a few individual engineers.

This situation sharply emphasizes the importance of inquiring into the grade of the material which goes into filing systems. If technical periodicals are to be clipped to build up files of data on stated subjects it is at once apparent that the material should be accurate and dependable, and that the less there is of duplication (reprinting) the less will filing systems be cluttered with duplicate data.

A library of books is a thing of beauty as well as of utility. The book itself is a convenient unit. Books published in large numbers are common property, available to all, and it is still another evidence of the growing complexity of life to witness the passing of the book as the main source of technical information. Corporations and files are creations of evolution.

The Institute has continued over a period of forty years to publish technical papers covering all departments of electrical engineering, and it is natural that in view of the vast changes and alterations which have in this period taken place in transportation, government, education, social conditions, etc., that a time would arrive when both the "matter" and the "manner" of engineering literature would be subjected to close scrutiny by engineers in close touch with historical perspective and world progress.

As time goes on our store of literature increases. The task of the student who searches through the literature of a subject becomes increasingly prolonged. Should the files increase proportionately in the next fifty years a situation might exist which would be serious.

There is now a tendency toward "outlines" and the Seven Foot Shelf. Outlines of History, Outlines of Literature, Outlines of Art, and Outlines of Science. This trend may hold the solution of the menace of vast accumulations of literature on given subjects.

A few scholars who have extraordinary capacities and the time for devouring endless tomes deplore these short cuts to omniscience, but as time and its productions pyramid, the engineer and the worker may come to view compilations and anthologies as boons.

To be well informed is becoming increasingly difficult. A time may arrive when consideration shall be given to constituting a Board of specialists charged with the duty of scrapping from reference libraries a large amount of material now catalogued and shelved. Future generations of engineers might then proceed unhampered by traditions and the dead weight of the past.

Until recently it has been not difficult for the engineer to acquire fairly definite ideas relating to the philosophy back of a law and to gain something of value in the way of a sensed professional association with the early philosophers and discoverers. Should modern systems of general education markedly influence the production of engineering literature it is probable that much of the inspiration experienced by past writers will be lost and that economic performances will form the criterion of achievement along literary lines as long other lines of endeavor

Duplication of Stories

A subject which some day is likely to receive attention is that of the very great amount of duplication of technical literature on single subjects. If the task of providing scientific literature could be organized so that each division of the arts would be covered continuously as new developments take place, the same constituted agency carrying the literature forward in point of time, it would be possible to avoid a deal of the expense of duplication.

Now, the weekly and the daily newspaper, popular magazine, trade journal and house organ reprint millions of words yearly when it would seem that the economical thing to do would be for all publications, other than the one of original source, to make brief reference to articles on special subjects, stating in what periodical published.

It is as if each periodical were a voice with nothing

particular to say, but willing to speak on any subject so long as there are paying listeners—readers.

The village artisan subscribes for the Home Clarion and looks to it to keep him posted on all subjects. The Clarion responding to opportunity becomes a market for an increased amount of syndicated material abstracted by hack writers little qualified to send forth accurate stories on technical subjects.

Tongues the world over wag continuously. Millions of words are spoken daily which do no more than supply vocal exercise. But, useless and purposeless spoken words may die aborning. Not so with the printed word. The printed word lasts as long as the paper on which it is printed. There is this difference between the spoken word that is useless and the written word that is useless. The latter has a high cost of production; lives long to mislead and confuse, and in its reading consumes ages of time which might be employed in better ways.

Writers who are on speaking terms with rejection slips have realized that in recent years the commercial technical journals are to an increasing extent following the policies favored by the higher class literary periodicals in so far as policies concern the acceptance of matter for publication.

From year to year the product of the will to write has increased. There is brought to the mill more grist than can be accomodated in periodicals conducted on an economical footing.

Much matter is left over the disposition of which is an embarrassment, in more than one sense.

The situation, together with editorial expediency, as trade winds blow or cease to blow, has resulted in a considerable portion of the matter accepted for publication being written on order or assignment.

The monthly journals of the large engineering societies appear to be the last open road for the individual writer who upon his own initiative and on his own time prepares a good story on a subject in which he is interested. Engineering journals are successful in a degree related to whether or not these stories are of interest to a sufficiently large number of their readers.

Those responsible for the character of material published in Engineering Society journals have no easy task. Their critics are numerous—all interested, not only in the journal but in the institute which the journal represents.

An element of the task is; not to discourage individual initiative. On the other hand, present costs of publication are such that the economics of the situation must be kept in view.

There are economic and mechanical limitations to the size of a periodical. A journal to be popular and to secure wide reading must be attractive in form and contain matter of interest to a large number of readers engaged in related activities. The subject matter must be spread out so that all corners of the field are covered] without intervals of neglect being too prolonged.

As the problems of Engineering Society journals approach in character the problems of commercial journals we are likely to see readjustments of editorial policies.

We may yet reach a stage where the managements of engineering journals functioning through institute technical committees will adopt a modification of the assignment system, whereby members of the Engineering Society will have subjects assigned to them in which they are recognized specialists—subjects which the managements know to be timely and of current value.

COMBUSTION TESTS WITH PULVERIZED COAL

The results of 36 combustion tests made on a 468-h.p. boiler fired with pulverized coal at a power station of the Milwaukee Electric Railway and Light Company, Milwaukee, Wisconsin, are given in Bulletin 223, just issued by the Department of the Interior, through the Bureau of Mines. The tests were made by the fuel section of the Bureau of Mines in cooperation with the research department of the Combustion Engineering Corporation. Illinois coal was used as fuel. The object of the tests was to obtain authoritative results of the performance of pulverized coal under various conditions of furnace operation and with coal of different fineness and moisture content. The results of the tests show that in this plant an over-all boiler efficiency of 80 to 83 per cent was obtained.

The rating that can be developed efficiently by a boiler depends almost entirely on the size and shape of the combustion space; this space is more effective if so arranged as to give the flames the longest possible travel through the furnace.

With this type of furnace and burners the most efficient rate of combustion is 1 to 1½ pounds of coal per hour per cubic foot of combustion space. Good results can be obtained between the rates of 0.6 and 2 pounds of coal per cubic foot per hour.

Combustion seems to be completed more rapidly if the flames impinge on hot refractory material, but such impingement causes excessive slagging and consequent erosion of the refractory.

Spreading burners seem to have caused less slagging, and to have given better results at higher rates of combustion than round burners. Slagging depends on the fusion point of the ash in the coal and on the furnace temperature; the latter rises with the percentage of carbon dioxide in the furnace gases. The ash in Illinois coal becomes soft and sticky at about 2,000 deg. fahr. and slag begins to form when the carbon dioxide in the flue gasses exceeds 10 per cent and the rate of combustion exceeds 1.3 pounds of coal per cubic foot of combustion space per hour.

Measuring Methods for Maintaining the Transmission Efficiency of Telephone Circuits

F. H. BEST

Member, A. I. E. E.
American, Tel. and Tel. Company, New York, N. Y.

***Review of the Subject.**—Maintenance of the transmission efficiency of the telephone plant is conducted by a special force using methods and apparatus that have been developed for this purpose. This paper gives a brief description of the transmission characteristics of some of the common types of telephone circuits, outlines a general method for measuring their transmission efficiency and describes several of the most modern types of transmission measuring sets together with a brief mention of the oscillators which supply the power for testing.*

* * * * *

THE circuits involved in the transmission of speech in a modern telephone plant, particularly those designed for long distance operation, necessarily involve a considerable amount of complexity. The use of telephone repeaters, the development of long toll cables, the application of carrier systems, and other developments associated with these, while increasing the efficiency and economy of telephone toll circuits, have also increased their complexity and have required the development of more effective means of insuring that the circuits are maintained at all times in good condition and adjustment.

It is the purpose of this paper to present a brief description of the measuring methods which have been developed and put into use, to enable those charged with the maintenance of such circuits to determine rapidly and conveniently whether the circuits are giving the transmission results for which they were designed.

Talking Tests

To a person who is unfamiliar with telephone transmission measurements, the most obvious method of testing a circuit is to talk over it. Such a method is not suitable for routine testing because of the impossibility of obtaining accurate data without taking elaborate and time-consuming precautions. It is impossible to judge at all accurately the efficiency of a circuit by simply listening to some one talk at the other end. Tests have shown that the most skilled observers cannot detect circuit changes which alter the received power by as much as a factor of three when these changes are made between conversations.

The only method of determining the transmission efficiency of a circuit by talking tests is to compare it repeatedly and directly with another circuit of known and adjustable efficiency. Experienced observers are necessary and much time is required to obtain accurate results. In the case of switchboard cord circuits and other central office apparatus, the total transmission loss is often less than the errors of measurement by this method. On long toll circuits, the errors of observation are small compared with the total loss and by careful tests with experienced observers, results sufficiently accurate for some purposes may be attained. The cost of this testing is, however, too great to permit its use on anything excepting important toll circuits.

Testing Line Circuits

The most accurate method of measuring a line circuit, such as a toll circuit, is to connect it as in Fig. 1 between a source of alternating current and a measuring instrument, both of which have impedances approximating the characteristic impedance of the circuit. With such an arrangement the unknown line becomes in effect part of an infinitely long line of its own type and the ratio of the voltages, currents or powers at the ends of the circuit is a measure of its transmission efficiency. In commercial use the toll circuit may be terminated by switching trunks or other circuits which have different impedances from that of the circuit which is being measured. In these cases terminal

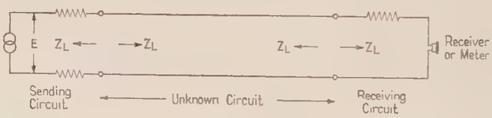


Fig. 1

losses, commonly called reflection losses, will result. As these losses are different for each impedance of the terminating apparatus, it is preferable for maintenance purposes to have them excluded. The measured results can then be readily checked by computations.

The transmission efficiency of the average telephone circuit is not constant with changes in frequency. Because of this a measurement of the transmission efficiency of a circuit with testing current of but a single frequency will not necessarily show the same result as would be obtained if the testing current were supplied by a voice actuated transmitter. In transmission maintenance work we are interested primarily in determining if the circuits are being maintained up to their specified standards. It is possible in many cases to determine this by means of a single frequency measurement or several measurements using testing currents of different frequencies.

Figs. 2 and 3 show the transmission frequency

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., February 4-8, 1924.

characteristics of two telephone circuits which have been chosen to contrast with each other, and to indicate the variations in type of the attenuation characteristic which may be found in a working plant. Fig. 2 shows the characteristics of a 13-gage, heavily loaded cable circuit. This circuit, while not characteristic of the loaded circuits now being installed, is loaded in accordance with the practise of a number of years ago, and is still in operation. Small irregularities in the spacing of loading coils produce irregularities in the transmission frequency characteristic of the circuit. While these irregularities are not serious in the case shown in Fig. 2, they are sufficient to cause a difference at any one frequency of as much as 2 miles of standard cable in two similar circuits which may have exactly the same equivalents for talking. More accurate results can be obtained by making several measurements at frequencies close together and averaging the results. Averages of such measurements on each of two similar circuits are generally in close agreement.

In addition to the irregularities shown on this circuit, it will be noted that the general trend of the curve from 200 to 400 cycles is downward, while for frequencies above 400 cycles it is upward. In this particular circuit the transmission equivalent for talking currents coincides with the single frequency measurement at about 1000 cycles and in this case a single frequency measurement at 1000 cycles would be a good indication of the talking transmission equivalent. A single frequency measurement at 1000 cycles would, however, not be a complete measure of the characteristics of the circuit including its distorting effect.

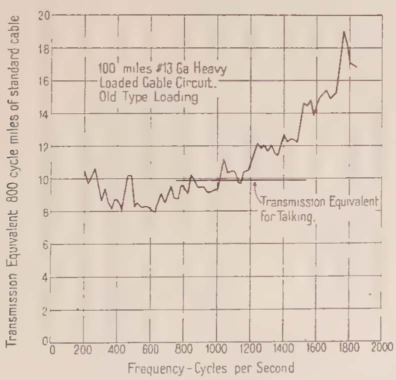


Fig. 2—Transmission Characteristic of 13 Gage Heavy Loaded Cable Circuit

Fig. 3 represents the transmission frequency characteristic of a non-loaded No. 8 B. w. g. open-wire circuit. It will be noted that this curve is quite different from that shown in Fig. 2. This open-wire circuit has no appreciable irregularities in its makeup and its general tendency is to transmit currents of different frequencies much more uniformly than the circuit shown in Fig. 2. In the case of this second circuit a 1000-cycle measurement also agrees with the talking transmission equivalent, but an observer talking over these two circuits would notice a difference in the quality of the transmitted speech. If it is desired to have an accurate picture of the distorting effect of the circuit as well as its volume efficiency, it is necessary to make a number of measurements over the entire voice frequency range.

In a majority of the toll circuits in the telephone plant a single frequency measurement is sufficient for routine purposes, the construction of these circuits being such that any defects which materially increase the transmission loss for talking will be evident at

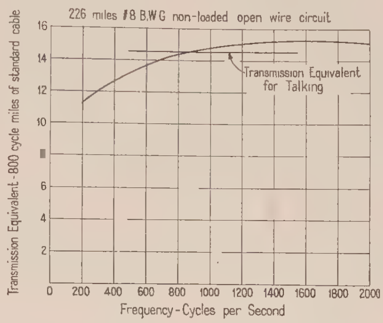


Fig. 3—Transmission Characteristic of No. 8 B. W. G. Non-Loaded Open Wire Circuit

nearly any single frequency in the voice range, although because of irregularities, it is not possible in many cases to determine the loss more closely than 2 or 3 miles of standard cable. However, there are some types of circuits, particularly the most modern types, in which it is possible by the opening of a single wire in a network or filter, or by some one piece of apparatus becoming defective to materially change the transmission-frequency characteristic for part of the frequency range only. In such cases as these, the talking volume as well as the distortion would be altered, although at certain single frequencies the circuit would appear to be normal. For such circuits, it is necessary for routine maintenance purposes, to make measurements at several widely separated frequencies in the voice range.

Testing Central Office Apparatus

The arrangement shown in Fig. 1 and described for line circuit testing can also be used for determining the transmission loss caused by a cord circuit or other piece of central office equipment under service conditions. If the generator and measuring instrument are connected directly together and then are connected by means of the cord circuit, the ratio of the currents in the measuring instrument for the two cases will indicate the effect of the cord circuit on transmission. By making the impedance of the generator and measuring instrument equal to the characteristic impedance of toll circuits of various types, the loss in received power caused by the cord circuit under different conditions can be readily obtained.

While in the case of line circuits it is necessary in some

cases to make several measurements using testing currents of different frequencies in order to determine the condition of the circuit, it is seldom necessary in central office apparatus to use more than one frequency of testing current. The reason for this is clearly shown in Fig. 4, which is the transmission frequency characteristic of a subscriber's operator's cord circuit. Curve *A* represents a normal circuit and shows the equivalent to vary only a small amount over the entire frequency range, the variation being gradual. If a large number of similar circuits were measured in this manner the same type of curve would be obtained for all of them which were not defective. Because of this, it is reasonable to assume that if two similar cord circuits have the same transmission equivalents for a single frequency of testing current, the two circuits will have approximately the same equivalents for voice frequencies.

Curve *B* represents the same cord circuit after one of the four windings of the transformer has been short-circuited, thus simulating the condition of a breakdown of the insulation between windings. This curve is also a smooth curve similar to curve *A* but higher at each point, the equivalent being approximately doubled at the more important frequencies. Because of the fact that a defect in one of the parts of a cord circuit usually increases the equivalent of the circuit at all frequencies, it is evident that a measurement of the equivalent at any one frequency of testing current is sufficient to indicate whether the cord circuit is normal or defective.

Practically all switchboard cord circuits and other central office apparatus such as phantom coils and composite sets have transmission frequency characteristics which vary in the gradual manner of the circuit in Fig. 4 and are affected at nearly all frequencies by a change in the electrical constants of any part.

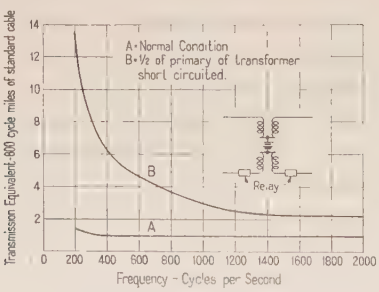


Fig. 4—Transmission-Frequency Characteristics of Subscriber's Operator's Cord Circuit

Tests with Artificial Cable

Although talking tests with artificial cable have not been in general use for a number of years, the method was applied for some time to important circuits and a brief description will be given.

The arrangement generally used is shown in Fig. 5. In this arrangement two telephone sets are connected by means of switches to the ends of the circuit under tests or to an artificial cable, the "length" of which is adjustable. In testing, one observer talks to the other at the opposite end of the circuit, talking alternately through the artificial cable and through the unknown circuit. The artificial cable is adjusted until the same volume of sound is received over each circuit. The number of miles of cable required to obtain a balance is said to be the transmission equivalent of the unknown circuit.

This method requires that both ends of the circuit under test be available at the testing point. Long circuits can then only be tested by connecting two of them together at the distant end and measuring them as one circuit. The amount of artificial cable when a balance is obtained represents not only the attenuation in the unknown circuit, but also includes reflection losses which occur at the junction of the unknown line and the substation instruments.

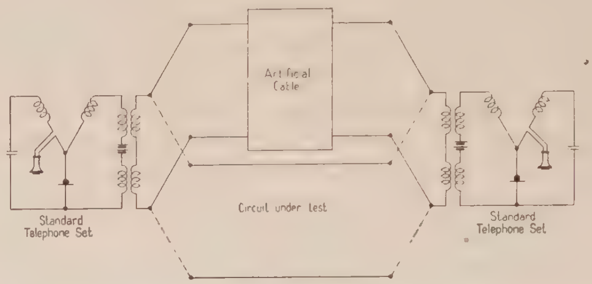


Fig. 5—Arrangement for Talking Test Using Artificial Cable

As toll circuits are seldom terminated directly by telephone sets, the reflection losses which occur in practise are generally not those occurring when tests are made by this method. One of the chief advantages of modern testing sets lies in the elimination of these reflection losses by the substitution for the telephone set of terminating impedances which approximate the characteristic impedance of the unknown circuit.

It is difficult to compare, from the standpoint of volume, two circuits which distort the speech in a different manner. Artificial cable has approximately the same distorting effect as some telephone circuits, particularly the oldest types, but it differs considerably from the latest types. In many cases, it is, therefore, difficult to obtain an accurate comparison of circuits by a talking test.

1-A Transmission Measuring Set

This was the first successful routine transmission measuring set to be developed to obviate difficulties and delays incidental to tests with artificial cable. Substation sets were eliminated as terminals and replaced with impedances adjustable to the characteristic impedances of representative circuits thus approximating the ideal of Fig. 1. The avoidance of reflection losses by characteristic impedance terminations also

enables the testing to be simplified by the use of single frequencies instead of the voice. This piece of apparatus and the alternating-current generator which supplies the testing current, are readily portable and entirely self-contained, being capable of operation without external batteries. It was designed, primarily, for the purpose of measuring the transmission loss under normal operating conditions of switchboard cord circuits and apparatus, and inter-office trunks. It was not intended for measurement of long toll circuits,

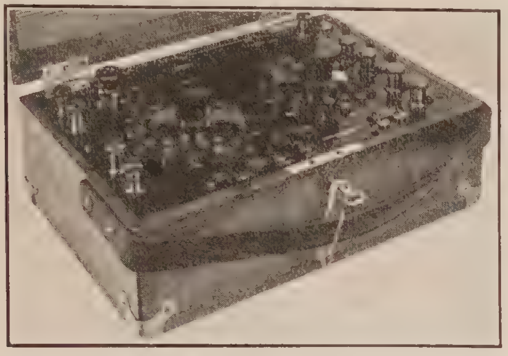


Fig. 6—1-A Transmission Measuring Set

although with limitations, it can be used for this purpose. An illustration of this set is shown in Fig. 6.

As shown in Fig. 7, the circuit consists of two branches which are permanently bridged together at one end. An alternating-current source is connected to the junction of these branches and the same voltage is, therefore, impressed upon each. The two branches are similar, except that in the upper one is connected the apparatus or circuit to be measured, while the lower one

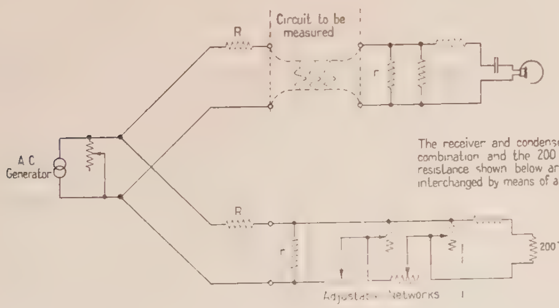


Fig. 7—Simplified Circuit of 1-A Transmission Measuring Set

contains an adjustable network for producing different transmission losses. A transmission measurement is made by adjusting the loss of this network until it is equal to that caused by the apparatus to be measured as determined by an equality of sound in a receiver when switched from one branch to the other. As the receiver is switched from one branch a 200-ohm resistance is substituted for it, this arrangement keeping the load on the alternating-current source and, consequently, the voltage at the junction of the two branches constant as the receiver is connected alternately to them.

Each branch is divided into two parts: A sending impedance designated R and a receiving impedance composed of r in multiple with the network to the right of r. The apparatus to be measured is connected between the sending and receiving impedance in the upper branch. The sending and receiving impedances in both branches can, by means of a key, be given any one of three values: 600, 1300 or 2200 ohms non-inductive, corresponding approximately to low, medium and high-impedance circuits, respectively. For transmission measurements, these values are sufficiently close to the characteristic impedance of telephone circuits.

The 1-A transmission measuring set cannot be used for testing circuits between offices, unless they are measured two at a time, the distant ends being connected together, as described in talking tests using artificial cable.

The adjustable network for producing different transmission losses is distortionless and consists of a series-shunt, non-inductive resistance arrangement of constant impedance as viewed from the source of power. It is so designed that the transmission loss can be adjusted in steps which cause the same change in the current as is caused by one mile of standard cable at a frequency of 800 cycles per second. This unit of transmission loss is known as the "800-cycle mile." The distortionless network is advantageous for transmission measuring purposes as it facilitates comparisons of the transmission efficiency of a circuit or piece of apparatus at different frequencies. Tests with artificial cable do not permit this.

The use of a single-frequency alternating current instead of the voice for testing enables comparisons to be made rapidly and quite accurately, it being possible to detect differences in currents as small as 2 per cent. (Approximately 0.2 mile of standard cable.)

The adjustable resistance connected across the junction of the two sending impedances and the alternating-current generator is for the purpose of controlling the sound in the receiver. It has no effect, from an impedance standpoint, on the results.

The two large dials shown in Fig. 6 adjust the loss of the distortionless network in half-mile and 5-mile steps. Directly above these are 3 smaller dials which control the volume of the testing current and the value of the sending and receiving circuit impedances. The binding posts and jacks are for the purpose of connecting the generator, receiver and circuits to be tested.

The actual operation of measuring consists simply in operating a key which connects the receiver alternately to its two positions and adjusting the network dials until the volume of sound is the same for both positions. The transmission equivalent of the apparatus or circuit under test is read directly from the dials.

3-A Transmission Measuring Set

At the time the 1 - *A* transmission measuring set was developed there were no alternating-current measuring instruments available for measuring the power received at the end of a telephone circuit which were sufficiently rugged or practicable to withstand the service required of them. The amounts of power at both the transmitting and receiving ends of a telephone connection are small. The sound energy produced by the voice during a telephone conversation varies over wide limits, an average figure expressed in electrical power units being of the order of 10 microwatts. Only a small part of this power reaches the transmitter, nevertheless, the transmitter being an amplifier, the power generated by it for this case is about 300 microwatts. The received power for an average connection is less than 1 microwatt and conversations may be carried on when the received power is as little as 0.01 microwatt.

The development and commercialization of the three-electrode thermionic vacuum tube made available a means for amplifying these weak currents sufficiently to enable them to be accurately read with standard types of meters. This tube also plays an important part in generators of alternating current for testing purposes. With suitable alternating-current generators and amplifiers available the problem of designing a transmission measuring set consists in arranging the apparatus in such a manner that it may be operated conveniently and rapidly and will measure accurately.

The transmission efficiency of a circuit may, as previously stated, be determined by measuring the currents or voltages at the two ends of the circuit. The ratio of these voltages or currents can then, if desired, be expressed in terms of standard cable. It is, however, much more convenient to have the result obtained directly, without computations. The principles used in the 1 -*A* transmission measuring set have, therefore, been followed in the more recent sets using vacuum tubes.

The 1 -*A* transmission measuring set requires for its operation, the maintenance of equal voltages on the two branches. As no voltmeter is provided, it is necessary to bridge the branches together to obtain equal voltages. This requirement prevents the measurement of circuits between offices unless two circuits are connected together at the distant end. The 1 - *A* set could be used for measuring such circuits if the branches were separated and equal voltages applied to them. In this case the upper branch *R* of Fig. 7 would be removed and connected to the distant end of the line under test and testing current supplied through it from a generator having a voltage equal to that of the generator connected to the lower branch.

The transmission measuring sets which employ vacuum tubes are arranged so that the voltage across the sending circuit impedances may be maintained at a definite value, a meter being connected in the oscillator circuit. It is, therefore, possible to make measurements on a circuit, in either direction, when a measuring set is connected to each end.

Several types of transmission measuring sets which make use of vacuum tubes have been developed but only the latest types of portable and non-portable sets will be described. The 3 - *A* transmission measuring set, a view of which is shown in Fig. 8 is a portable set designed to replace the 1 - *A* transmission measuring set in common battery central offices where a direct-current supply is available to operate the vacuum tubes. Like the 1 - *A* set, it is intended primarily for measuring central office apparatus and switching trunks. The maximum transmission equivalent which can be measured is 30 800-cycle miles.

Fig. 9 shows the circuit arrangement used in measuring the transmission equivalent of a circuit between two offices, this type of test being commonly called a "straightaway" test, as differentiated from the "loop"

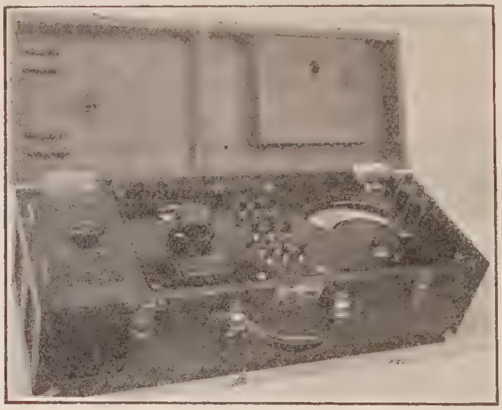


Fig. 8—3-A Transmission Measuring Set

test used with the 1 - *A* set and with talking tests. At the sending end of the circuit only part of the apparatus is in use, as shown. The sole purpose of this apparatus is to impress a voltage across the terminals $C_1\,C_1$. The impedances D_1 together approximate the characteristic impedance of the unknown circuit. The a-c. meter shown in this drawing is a thermo-milliammeter which can, of course, be used in measuring voltage if the resistance of the circuit is known. If the milliammeter were in series with the resistance H_1, shown connected across terminals $C_1\,C_1$, the reading of the meter would be proportional to the voltage. But such an arrangement is undesirable because the impedance of the meter would be important. For practical reasons it is desirable to have the meter where the total current through both H_1, and $D_1\,D_1$, is measured. However, the resistance of H_1 is so small, with respect to $D_1\,D_1$, and the unknown circuit, that practically all of the current is in H_1, and changes in the impedance of the unknown circuit produce a negligible effect on the voltage across

$C_1 C_1$. H_1, then serves the purpose of a generator of low impedance, this arrangement being referred to as a "point source" approximation.

At the receiving end of the circuit the complete transmission measuring set is required. The principal parts of the set are shown in the dotted rectangle to the right of the unknown circuit. They consist of an amplifier-detector unit for amplifying the weak received testing current and converting it into direct current, a meter which is actuated by the rectified current, a sending circuit identical with that used at the sending end of the unknown circuit, and two branches containing networks known as the "calibrating" and "measuring" networks.

The purpose of some of these parts, particularly the calibrating network, will not be evident to those unfamiliar with vacuum tubes. The vacuum tube, while an excellent amplifier and rectifier, cannot be relied on to maintain unvarying characteristics. The characteristics of a tube change slightly with time for several moments after the filament is energized. There is also the effect of long continued use. A still greater change in an amplifier is occasioned by replacing tubes, even in the case of tubes used in telephone circuits where a high degree of uniformity is required. Because of these variations a vacuum tube amplifier acts in a manner similar to that of a meter in which the resistance of the meter and the tension of the springs are subject to variations.

Transmission measuring sets must be designed to operate on power available at a central office. The voltages of the batteries used for telephone work are allowed to fluctuate between fairly broad limits, the difference between the maximum and minimum voltages being about 25 per cent. This change in voltage usually takes place slowly as the batteries are charged, nevertheless the effect of voltage change in the plate circuit of a vacuum tube is shown directly in its amplification.

It should not be inferred that a vacuum tube amplifier is a continuously fluctuating instrument for this is not the case. After the tubes have been operating for about 15 minutes, and at times when the battery voltage is constant, the amplification factor of an amplifier will remain practically constant for some time. The changes experienced are more of an hour to hour or day to day change, but are sufficient to require the provision of an arrangement whereby the amplifier may be regulated.

The amplifier-detector unit is adjusted by connecting the sending circuit directly to its own receiving circuit, the switches being thrown as indicated by the solid lines of Fig. 9, thus bringing the calibrating network into the circuit. The impedances $D\,D$ and H in the sending circuit are set for the same values as $D_1\,D_1$ and H_1 of the sending circuit at the distant end of the unknown line. As previously stated, $D_1\,D_1$ together approximate the characteristic impedance of the unknown line. The sending circuit currents are both adjusted to the same value. The calibrating network is designed to cause the same loss as is caused by 30 800-miles of standard cable, this being the maximum transmission equivalent for which this set is designed. The reduced voltage from the output terminals of the calibrating network is applied to the input of the amplifier-detector unit, is amplified and rectified and produces a deflection on the meter. By means of the "adjusting dial" the deflection is brought to mid-scale. When this condition holds the apparatus is said to be "calibrated", which means that when a given e. m. f. is applied to the terminals $C\,C$ in the sending circuit, and the resulting current attenuated by the calibrating network, a mid-scale deflection is obtained on the meter.

The receiving circuit now being in a condition to measure the unknown circuit, the switches are operated to the dotted position. By this operation the receiving end of the unknown circuit is connected to the transformer K and the calibrating network is replaced by the adjustable measuring networks. While the power in the unknown circuit at the sending end is the same as that supplied to transformer K in calibrating, the unknown circuit attenuates this power so that the power supplied to the adjustable networks is less than that supplied to the calibrating network. Consequently, to obtain a mid-scale deflection on the meter as in calibrating, the loss in the adjustable networks must be reduced, from that of the calibrating network, by an amount equal to that caused by the unknown

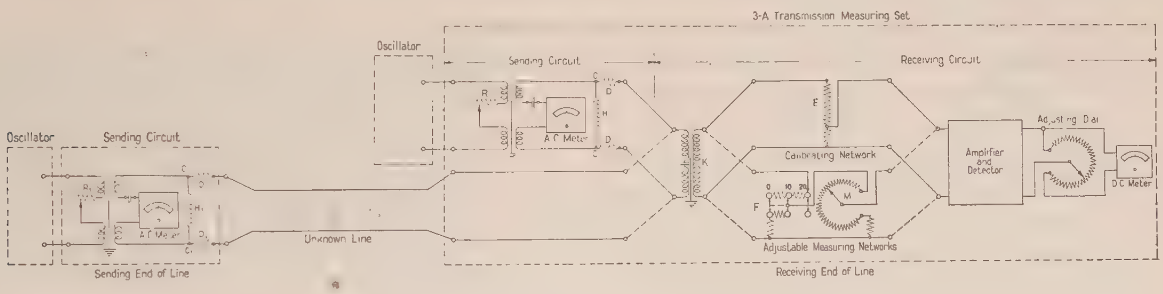


Fig. 9—3-A Transmission Measuring Set

Simplified Diagram Showing Arrangement for Straightaway Tests.
Solid Position of switches show corrections for calibrating. Dotted position of switches show corrections for measuring.

circuit. By calibrating the adjustable networks to indicate this reduction, the transmission equivalent of the unknown circuit can be read directly.

As long as the amplification of the tubes remains constant other circuits may be measured without recalibration, the only operation required being the adjusting of the measuring networks until a mid-scale reading is obtained. It is evident that this method of measurement is more rapid and more satisfactory than a method which requires the reading and calculation of currents and equivalents.

In the transmission measuring sets the amplified current is converted into direct current by means of a rectifier or detector, it being customary to use a standard amplifying tube for this purpose. For a given amplifier the deflection obtained on a sensitive d-c. meter using rectified currents is about the same as would hold with a thermal meter if the current were not rectified. The d-c. meter operating on rectified current has an important advantage over a thermal meter in that it operates more rapidly and it is chiefly for this reason that it is used.

There are numerous other details of the 3-*A* transmission measuring set which are of interest and a few of them will be mentioned. Among the most important of these are the transformer *K* and the transformer in the sending circuit. Each of these transformers has an electrostatic shield between the windings, the shield being connected to ground. The purpose of these shielded transformers is to furnish paths of equal admittance to ground from the two wires of the testing circuit, thus preserving the balance of that circuit. The transformer in the sending circuit prevents any unbalanced current being sent into the line, due to unbalances which may exist in the oscillator. The transformer *K*, in the receiving circuit prevents any unbalance currents which may be induced in the unknown circuit from acting on the unbalanced networks and amplifier. It also prevents the receiving circuit from unbalancing the line.

The adjustable network *F* is a constant impedance non-inductive resistance network. The impedance of *F* is 600 ohms at all times as viewed from transformer *K*. This transformer has an impedance ratio of approximately unity, the departure from unity being such that the combination of network and transformer impedance is 600 ohms when measured from the terminals to which the unknown circuit is connected. The impedance of the receiving circuit is normally 600 ohms but can be made 1200 or 1800 ohms by connecting resistances between the transformer and the switch. The impedances in the sending circuit can be given these same values. Two of these impedances differ from those of the 1 - *A* transmission measuring set, being based on conditions now existing in the telephone plant.

The adjustable network *M* is a potentiometer of unusual design. It is made in the form of a circular slide wire, the resistance wire being wound on a mandrel of non-uniform cross-section so that the change in resistance when rotating the drum on which the mandrel is mounted will be logarithmic. The attenuation of a long uniform telephone circuit is represented by the expression $e^{-L\alpha}$ in which L is the total length and α the attenuation per unit length. This is a logarithmic expression and requires a logarithmic variation of the resistance on a slide wire if uniform divisions are to be obtained.

Both networks *E* and *M* are designed on the assumption that the impedance of the amplifier is so high with respect to the networks that it may be considered infinite. This condition is met by the amplifier, the input transformers having high-impedance windings.

The 3 - *A* transmission measuring set operates entirely from the 24-volt central office battery as a source of power for both the filament and plate circuits of the tubes. The energy required by the meter is so small that tubes operating on this low voltage will carry it without danger of overloading them. However the circuit of the amplifier is so arranged that the maximum energy which the tubes will deliver is not sufficient to damage the meter.

Although two meters are shown in Fig. 9 only one is used in the 3 - *A* set. This meter is a microammeter which measures direct current in the detector circuit of the amplifier and, in conjunction with a thermocouple measures, in milliamperes, the current in the sending circuit. It also is used with a shunt to measure filament current. Arrangements are provided so that in case a thermocouple is replaced the combination of meter and couple can be calibrated without the use of an additional meter.

The actual operation of the 3 - *A* set is simple and rapid. The 9 keys shown in Fig. 8 control the sending and receiving circuit impedances, switch from the measuring to calibrating condition, and perform several other minor operations. The two dial handles, mounted concentrically, control the adjusting dial used in calibrating and the network *M* used in measuring. The scale on dial *M* is shown directly above the dial handles.

The dial handle at the extreme left controls a rheostat which regulates the oscillator current in the sending circuit, being designated as R and R_1 in Fig. 9. The vacuum tubes and filament rheostat are in the compartment below this dial handle.

The binding posts and jacks at the extreme right are for the purpose of connecting the circuits to be tested to the measuring set. The jacks are used for cord circuits which terminate in plugs.

4-A Transmission Measuring Set

The 4 - *A* transmission measuring set is a non-portable set designed for routine measurements on toll circuits. It will measure transmission losses as great

as 60 800-cycle miles and will also measure the gain of a telephone repeater. A view of the set is shown in Fig. 10.

The 4 - A set resembles the 3 - A set electrically in so many details that it is unnecessary to show any schematic circuit. It consists of an identical sending circuit and a receiving circuit which differs only in two important respects, both of these being in the amplifier.

The range of the set being double that of the 3 - A set makes it necessary to provide an additional stage of amplification. This extra range means also that the magnitude of the power received from many of the circuits under test is much less than that which is received in the case of the 3 - A set. Toll circuits are often exposed to induction from power circuits, sometimes resulting in induced currents of a magnitude which in the case of high transmission equivalents, approaches that of the testing current. Even when the equivalent of the toll circuit is low, such as is usually the case, these induced currents may cause serious errors. The induced currents add to the testing current and cause the toll circuit to appear to have a

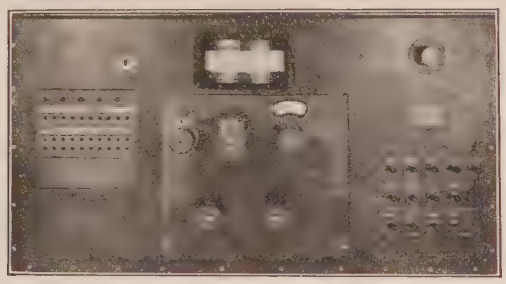


Fig. 10—4-A Transmission Measuring Set

smaller transmission equivalent than it actually has. In order to minimize the effect of induced currents a network of condensers and inductances, known as an electrical "filter" is provided in the amplifier circuit. This filter greatly attenuates all frequencies except those within a narrow band used for testing purposes and enables measurements to be accurately made on nearly all circuits. Special filters may be required when measurements are made over a wide range of frequencies. However, for routine measurements where a single frequency or narrow band of frequencies is employed, little difficulty is experienced when the filter in the 4 - A set is used. The filter is located between the first and second tubes in the amplifier. With this arrangement the filter can be changed at will without the resulting changes in impedance appreciably affecting the impedance of the amplifier as a whole, considered from the terminals to which the measuring and calibrating networks are connected. The 3 - A set having no filter, is not well adapted to testing circuits which are subject to induction.

In addition to the increased range the 4 - A transmission measuring set differs chiefly from the 3 - A set in having facilities for enabling the tester to talk over circuits and to the toll operator whose duty it is to establish a connection between the measuring set and the toll circuits.

The vacuum tubes operate from the central office battery as a source of power for the filaments. The plate potential is supplied by the central office battery and an 18-volt flashlight cell battery.

Fig. 11—2-A Oscillator

Oscillators Used with Transmission Measuring Sets

While it is not the purpose of this paper to give a detailed description of the oscillators used with transmission measuring sets a brief statement about each will enable a more complete picture to be obtained. Fig. 11 shows a photograph of the 2 - A oscillator

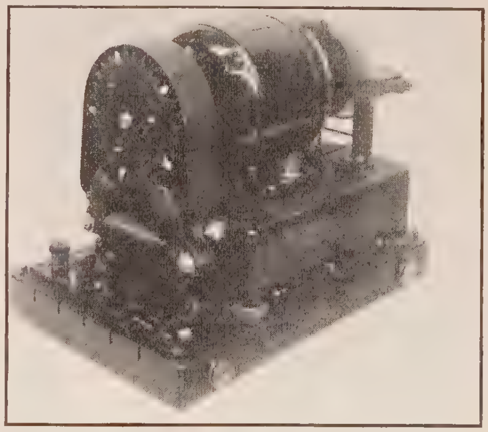


Fig. 12—3-A Oscillator

which furnishes testing current for the 1 - A transmission measuring set. This oscillator contains three dry cells which supply power to operate a vibrating reed type of carbon button generator. A single-frequency current of 800 cycles is obtained.

Fig. 12 shows a photograph of the 3 - A oscillator used with the 3-A transmission measuring set. This is a motor-driven inductor-alternator which operates

from the 24-volt central office battery as a source of power. It generates a single-frequency current of 1000 cycles. The speed of the motor is regulated by a governor.

Fig. 13 shows a photograph of the 4 - *B* oscillator which is used with the 4 - *A* transmission measuring sets in making measurements at frequencies between 100 and

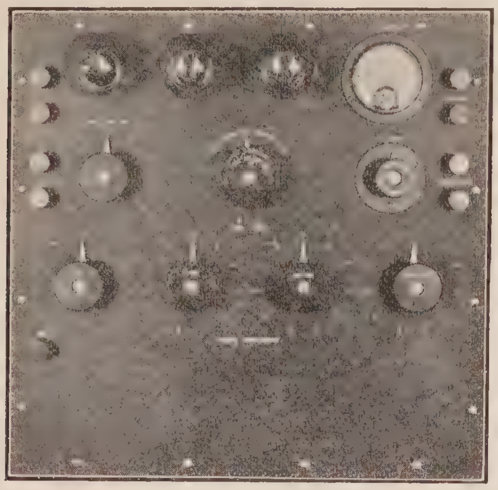


Fig. 13—4-B Oscillator

3000 cycles. This oscillator is of the vacuum tube type and is conveniently arranged so that any frequency may be easily obtained.

Fig. 14 is a photograph of the 5 - *A* oscillator which has been designed for routine measurements on toll

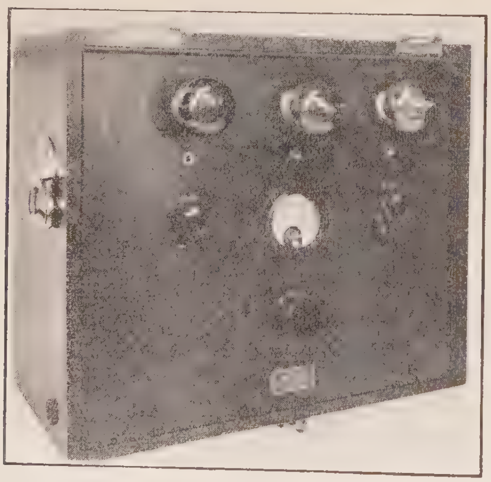


Fig. 14—5-A Oscillator

circuits in cases where it is not necessary to make measurements over a wide range of frequencies. This oscillator is of the "frequency-band" type, the generated current varying in frequency continuously and periodically between 900 and 1100 cycles per second in a manner similar to a siren. The results obtained with this oscillator are the same as the average of a number of single-frequency measurements between these same frequency limits. This oscillator is of particular value in the case of circuits of the type shown in Fig. 2. The frequency is varied by changing the inductance of an inductometer in the oscillating circuit, the shaft on which the moving part is mounted being rotated by a motor.

Conclusion

The development of these transmission measuring sets and associated oscillators has placed in the hands of telephone operating forces convenient and practical tools which enable them to properly maintain the talking efficiency of telephone circuits. Widespread use has demonstrated that the resulting transmission savings and improvements in service are worth many times the cost of doing the work.

ELECTRICAL DEVELOPMENT IN SOUTHERN ITALY

Undoubtedly the most constructive of all the measures now being developed for the industrial advancement of Southern Italy is that for the artificial lakes in the Sila Plateau which is now well under way. This plateau reaches an altitude varying from 4,160 ft. to 6,080, covering an area of some 450 sq. miles. Two dams are being built forming a lake with a content of 500 million cu. ft. of water and another with a content of 200 million, connected by a tunnel over a mile long piercing the Monte Nero. These works when completed will supply a constant average of 160,000 h.p. Five electric central stations will be fed by this hydraulic power, the largest of which at Timpa Grande on the river Neto is already being built. It will generate a constant average of 85,000 h.p. and will be equipped with engines of 140,000 h.p. This power scheme includes plans for irrigation. Two storage dams will be built with their respective irrigation canals and ditches serving an area of 24,000 acres in the Piana di Cotrone where land reclamation schemes approved by the Ministry of Public Works are now being undertaken.

These works, when completed, will supply power at low rates which will be carried by three main cable lines at a tension of 150,000 volts to Sicily, Apulia, and the Naples district, besides supplying the industrial needs of the Calabrian provinces. These at present call for some 20 to 25 thousand h.p. of the 160,000 which will be made available. The first central station generating 100,000 h.p. is expected to be inaugurated at the close of 1925.

36,000 LAMPS FOR FIVE SIGNS

A press notice appearing in various newspapers imparts the information that five of New York's electric signs require a total of 36,000 electric lamps which consume about 900 kilowatts of electricity. This is roughly twice the amount of electrical power used in the entire country in 1881.

Effects of Time and Frequency
on Insulation Test of Transformers

BY V. M. MONTSINGER
Associate, A. I. E. E.
Transformer Engineering Dept., General Electric Co.

Review of the Subject.—*Permanently grounded transformers must be given the insulation test by inducing the necessary voltage across the windings.*

The A. I. E. E. Standards specify that the time of induced voltage tests be the same as for high potential test. In certain cases where the transformers are of very large capacity the induced voltage must be made at a frequency several times higher than normal. Since the dielectric strength of most insulating materials decreases with an increase in the frequency, an investigation has been made to determine the proper and fair length of time to make induced voltage test when the frequency is higher than normal.

Following are the main points brought out in the investigation.

Above a certain voltage, ***time*** *of voltage application as well as* ***voltage*** *causes failure of insulation. The dielectric strength can be expressed as a function of both* ***time*** *and* ***voltage*** *by an equation of the form*

$$Kv. = A\left(a + \frac{1-a}{\sqrt{T}}\right)$$

in which A is the kilovolts necessary to cause failure in one minute, "a" is a constant representing the ratio of strength for infinite time to the one minute strength and T is time in minutes. The value of "a" varies for different materials apparently depending mostly on the dielectric loss.

The breakdown by creepage over solid insulation with the electrodes either on the same side or on opposite sides of the sample (arranged in such a manner that the solid insulation is under considerable stress) is not affected by ***time*** *nearly so much as is the puncture voltage of solid insulation.*

The behavior of oil without barriers is so erratic that no very definite relation can be obtained between ***time*** *and dielectric strength. In general* ***time*** *decreases the strength quite rapidly for the first few seconds after which the effect decreases and probably disappears entirely after two or three minutes. The momentary strength ranges from 25 to 30 per cent higher than the one minute strength.*

The effect of ***time*** *on the strength of solid insulation and oil in series is about the same as for solid insulation alone until the oil distance exceeds the solid insulation thickness after which it begins to be the same as for oil without barriers.*

The strength-time curves for solid insulation are of approximately the same shape for all frequencies from 60 to 420 cycles, although the strength decreases with an increase in frequency F approximately in accordance with the formula $kv. = 1.75 / F^{0.137}$

Failure by creepage over the surface of solid insulation which is under no stress (i. e., with the electrodes on the same side of the barrier) takes place at approximately the same voltage for all frequencies from 60 to 420 cycles; but if the electrodes are so arranged (on opposite sides) that the insulation is under considerable stress the failure voltage decreases with an increase in frequency in about the same order as the puncture voltage of solid insulation does.

The rupture voltage of oil is the same for both 60 and 420 cycles.

The effect of frequency on the puncture voltage of solid insulation and oil in series is the same as for solid insulation until the oil distance exceeds the thickness of solid insulation, after which the effect decreases and as the oil distance increases the effect approaches that for oil without barriers.

By considering the effects of both time and frequency on dielectric strength it is shown how to determine the proper length of time to make the voltage strain at higher frequencies equal to the strain at 60 cycles for one minute.

Introduction

SECTION 6362 of the 1922 edition of the A . Standards reads as follows:

> *Testing Transformers by Induced Voltage*—Under certain conditions it is permissible to test transformers by inducing the required voltage in their windings in place of using a separate testing transformer. By "required voltage" is meant a voltage such that the line end of the winding shall receive a test to ground equal to that required by the general rules.

The increased number of permanently grounded transformers within the last few years has resulted in an increased use of the induced potential method for testing the insulation. In case the transformers are single phase, and when required to impose a strain equal to twice line potential on the end of the windings the induced voltage must be $2\sqrt{3}$ or 3.46 times normal. To keep the exciting current within a reasonable value at this high induction, the frequency must, of course, be greater than the rated frequency.

To maintain normal 60-cycle density at 3.46 times normal voltage requires 60×3.46 or 208 cycles. An idea of the large generator capacity required for testing some of the largest transformers of today when using, say, 208 cycles may be had from the following example: Assume a 30,000-kv-a., 60-cycle single-phase transformer to be given 3.46 times normal induced voltage. If the exciting current is 5 per cent of full-load current and to maintain normal iron density the necessary single-phase 208-cycle generator capacity would be $30,000 \times 3.46 \times 5 / 100 = 5200$ kv-a. As the generator should be three phase and as the single-phase rating is usually taken as 70 per cent of the three-phase rating the total capacity required would be $5200 \times 100 / 70 = 7450$ kv-a. This rating of course would be required only for intermittent service and an overload could be had, which would permit of reducing the continuous rating to possibly 5000 kv-a. Even this generator capacity of this odd frequency is out of the question for test purposes.

Since the exciting current decreases very rapidly with iron density the most practical thing to do in testing very large units, of course, is to use a generator of higher frequency than 208 cycles. In certain cases this has been done and with the consent of the customer, 420

To be presented at the Midwinter Convention of the A. I. E. E., Philadelphia, Pa., Feb. 4-8, 1924.

cycles has been used with a reduction in the time of voltage application to give a total of 7200 cycles. This investigation shows that this test amply meets the standard insulation requirements.

It is obvious that, except for liquid insulations, to produce the same voltage strain, the *time* should be reduced as the frequency is increased, since dielectric loss increases with frequency and the heating is increased, and consequently the dielectric strength is reduced. But just how much the *time* should be reduced to make the tests at different frequencies of equal severity had not been extensively investigated on built up transformer insulations until recently. Based on the tests which had previously been made and on the results shown by F. W. Peek (pages 179, 182, 183 and 184 in *Dielectric Phenomena in High-Voltage Engineering*) we have considered that the voltage strain at different frequencies was approximately the same if the time was inversely proportional to the frequency. In fact it is logical to expect that within certain time limits the strain should be somewhat more severe for the higher than for lower frequencies for the reason that there is less chance for the heat in the solid insulation to escape. The results of this investigation bear this out as will be shown later.

The object of this paper is to give the results of a large number of tests made on solid insulation, built-up insulations and oil, and based upon these results to show the relation between the time of voltage application at different frequencies to produce approximately the same voltage strains on the classes of insulating materials commonly used in oil-immersed transformers. It is hoped that the data, especially the strength-time curves, will be useful not only for transformers but for other types of electrical apparatus.

As would be expected, it was found that the ratio of time necessary to cause failure at any two frequencies changed as the time of voltage application increased. For example referring to Fig. 23 and assuming for the moment that these curves which show the relation between *time*, frequency and dielectric strength, are correct, it will be seen that a test for 30 seconds at 25 cycles is equivalent to a test for 4 seconds at 120 cycles. In other words the ratio of time here is 7.5:1. However, these curves also show that a test for three minutes at 25 cycles is equivalent to a test at 120 cycles for 10 seconds. Here the ratio of time is 180 / 10 or 18:1 which is more than twice that for the first case. Likewise as the time chosen at the lower frequency for comparison becomes longer the ratio between this time and the time that gives an equivalent voltage strain at the higher frequency becomes larger and larger until finally the ratio becomes infinity.

Factors Considered in Experimental Observations

Test Factors.—Since the ratio of time changes for different frequencies it was of course necessary to determine the variation of dielectric strength with "time of voltage application" as well as the effect of frequency on the dielectric strength for a given time and voltage.

b. Insulation Factors.—When a transformer fails on insulation test it is usually due to one or a combination of the following causes:

1. Puncture of solid insulation
2. Creepage over solid insulation
3. Rupture of oil and
4. Puncture of solid insulation and oil in series.

The above four causes of failure have been investigated in determining (1) dielectric strength vs. time of voltage application and (2) dielectric strength vs. frequency.

Empirical Formula of Strength-Time Curves

An examination by the writer of all available strength-time curves made at different frequencies showed that these curves can best be expressed by an equation of the form first suggested by Peek (see page 179 *Dielectric Phenomena in High-Voltage Engineering*). The equation is:

$$E = \left[a + \frac{(1 - a)}{4 \sqrt[4]{T}} \right]$$

In which E is the ratio: "dielectric strength at any time divided by the strength for one minute," and a is a constant representing the ratio: "one minute dielectric strength divided by the strength for infinite time," and

T = time in minutes.

The above equation means, of course, that the dielectric strength decreases with time of voltage application in accordance with an exponential equation (of a straight line on double logarithmic paper) until whatever causes[1] failure, ceases to affect the strength. In other words the curve becomes parallel to the axis of time before the strength reaches zero, otherwise electrical apparatus having insulation under a constant moderate stress would fail in time due merely to this stress. We know, however, that this does not happen.

It would, of course, be expected that the value of a in equation (1) would be different for different materials depending probably in part on the density and partly upon dielectric losses. It is natural that the higher the loss the more quickly will the curve flatten out. The following tabulation gives maximum, average, and minimum values of a, and the densities for some of

1. Space and time do not permit of attempting to discuss why *time* and frequency affect the dielectric strength of insulation. This question, however, is being actively studied and it is hoped that at some future time something can be given on this very interesting and important subject of the mechanism of breakdown.

the usual insulating materials used in transformers and tested in this investigation.

Materials in oil	a	Density
0.003 in. untreated cable and kraft papers	0.85	0.7 to 0.8
0.012 in. varnished cambric (1 to 10 layers)	0.675	1.12
0.005 in. varnished bond paper (6 or 7 layers)	0.675	1.12
Combination of 3/32 in. pressboard and 3/32 in. oil ducts in series	0.675	
Pressboard at 75 and 100 deg. cent.	0.675	0.95—1.05
Pressboard at 25 deg. cent.	0.50	0.95—1.05

It will be noted from the above that the values of a do not appear to bear any definite relation to the

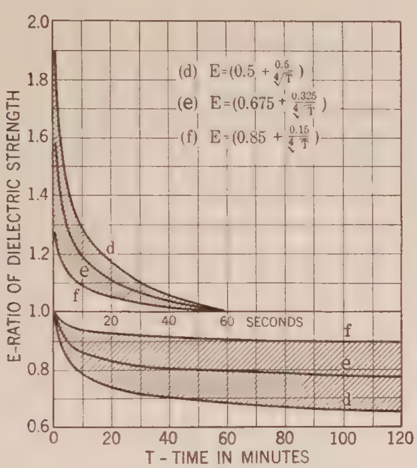


FIG. 1—STRENGTH-TIME CURVES PLOTTED FROM FORMULA: $E = \left[a + \frac{(1-a)}{\sqrt[4]{T}}\right]$ IN WHICH "A" IS A CONSTANT DEPENDING ON THE MATERIAL

density of the material. Probably dielectric loss is one of the main factors since paper generally has a high loss as compared with pressboard especially at 25 deg. cent.

Table No. 1 gives in tabulated form the ratios of dielectric strength calculated for different times T and for maximum average and minimum values of a in equation. (**1**).

TABLE NO. 1

EFFECT OF TIME ON RATIO OF DIELECTRIC STRENGTH CALCULATED BY EQUATION. (1) FOR E =

T-Time in: Sec.	Min.	$\left(0.85 + \frac{0.15}{\sqrt[4]{T}}\right)$	$\left(0.675 + \frac{0.325}{\sqrt[4]{T}}\right)$	$\left(0.5 + \frac{0.5}{\sqrt[4]{T}}\right)$
1	0.0167	1.27	1.587	1.90
3	0.05	1.167	1.36	1.556
5	0.0833	1.13	1.278	1.43
10	0.167	1.084	1.182	1.28
20	0.333	1.048	1.105	1.16
30	0.5	1.03	1.062	1.095
60	1.0	1.00	1.00	1.00
	2.	0.976	0.95	0.92
	5.	0.95	0.89	0.833
	10.	0.934	0.858	0.78
	30.	0.914	0.814	0.714
	60	0.904	0.792	0.68
	120	0.895	0.77	0.65
	infinity	0.85	0.675	.50

Fig. 1 shows the data in Table No. 1 plotted in curve form. The shaded area or envelope of these curves represents the variations in dielectric strength with time of voltage application, that is likely to be obtained from representative Class A insulating materials used in electrical apparatus.

If desired to express the dielectric strength in kilovolts rather than by ratio values the form of the equation becomes

$$\text{Kv.} = A\left[a + \frac{(1-a)}{\sqrt[4]{T}}\right] \qquad (2)$$

in which A is the one minute dielectric strength in kilovolts. a, and T have the same significance as in equation (**1**).

To have some convenient yard stick for measurement as we go along, all test data shown later will be compared with the values calculated by equation (**2**) using either the minimum, average or maximum value of a according to the one that fits best.

EXPERIMENTAL 60-CYCLE STRENGTH-TIME CURVES

Unless otherwise stated the voltage was applied to the sample by closing the field switch of the generator with the rheostat set for some predetermined value. An investigation showed that this is the only method

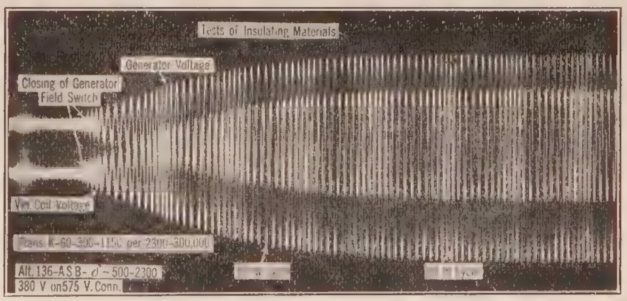


FIG. 2—OSCILLOGRAM SHOWING RATE AT WHICH 60-CYCLE TESTING TRANSFORMER VOLTAGE INCREASED TO A STEADY VALUE AFTER CLOSING GENERATOR FIELD SWITCH

It will be noted that no surge took place

of obtaining full voltage in a short time without producing an initial surge such as we know happens at times when full excitation is thrown on the primary side of a testing transformer. Tests showed also that a disturbance took place when full voltage was thrown across the electrodes by closing the circuit on the secondary side of the transformer while the transformer was excited.

The time given is that from the instant of closing the field switch until failure occurred. An oscillogram of the initial voltage waves, Fig. 2, shows that it required approximately one second for the voltage to build up to a constant value. The true value of time is probably from one-half to one second less than that shown.

All tests in this investigation were made with the

samples in a vertical position. The pressboard in all cases contained approximately 45 per cent of rag material.

The 2-in. and 4-in. diameter electrodes had a 3/32-in. and ½-in. curvature radius respectively on the edges. All kilovolt values given are the r. m. s. values of the peak of the wave as determined by spark gap.

a. Solid Insulation. Table II gives the comparison of calculated values and results of tests made on oil-treated, three-mil kraft papers.

It is, of course obvious, that, since the value of the constant a used for calculation was obtained from these tests, a comparison between the calculated and test results shows only how the curves agree with each other and how closely they can be expressed by an empirical formula.

TABLE II.

VARIATION OF DIELECTRIC STRENGTH WITH TIME OF APPLIED VOLTAGE. 60 CYCLES

2-in. round edged electrodes in oil at 25 deg. cent. Effective sine wave values. Average of 10 tests. Material 0.003 in., oil treated kraft paper.

Test No. 1—7 layers

Time in Sec.	Puncture Kv. Test	Puncture Kv. Calc.*	
2	24	25.2	
7.5	22.5	23.3	
16	22	22.4	
21.5	21.5	22	
60	21.1†	21.1	
95	21	20.8	
No break in 180	20.5	20.4	(one trial)

Test No. 2—6 layers

Time in Sec.	Puncture Kv. Test	Puncture Kv. Calc.*
4	19	19
10.1	18	18.2
24.5	17.5	17.5
46.5	17	17
60	16.9†	16.9
160	16.5	16.4

Test No. 3—6 layers

Time in Sec.	Puncture Kv. Test	Puncture Kv. Calc.*	
1	24	22.2	
4	22	20.2	
11.5	20	19	
49	18	17.7	
60	17.6†	17.6	
99	17.0	17.3	
168	16.5	16.9	
No break in 2 hrs.	16.0	15.8	(one trial)

*Kv. = one min. Kv. $(0.85 + 0.15 / \sqrt[4]{T}$ This has the same constants as given by Peek for paper covered cables referred to previously.

†Estimated by interpolation.

Figs. 3 and 4 show two sets of strength-time curves obtained on single sheets of 3/32-in. pressboard in 25 deg. and 75 deg. cent. oil. The 75 deg. curve checks the average value of a while the 25 deg. curve agrees better with the minimum value of a. The writer has found that pressboard at 25 deg. cent. shows the greatest variation in strength with *time*, of any material tested, but at 75 and 100 deg. cent. (as will be shown later) the variation in strength corresponds to the average value of a. In making any tests at higher than room temperatures, the material was subjected to the tested temperature for at least 24 hours before being tested in order that the condition of the material would not change while undergoing the test.

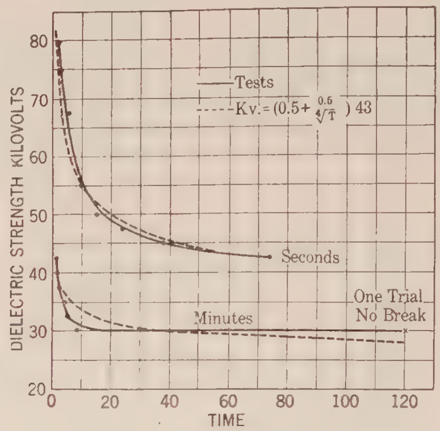


FIG. 3—60-CYCLE STRENGTH-TIME CURVE

One layer of 0.0935-in. oil-treated pressboard in oil at 25 deg. cent. Each point average of 10 tests. Time for voltage to build up (approx. 1 sec.) included 2-in. diam. electrodes

However, for most other materials such as varnished bond paper having a smooth film of oxidized varnish over the surface and for varnished cambric, the test curves check best the average value of the constant a from 25 deg. to 100 deg. cent. Figs. 5 and 6 give results of tests made on varnished bond paper and

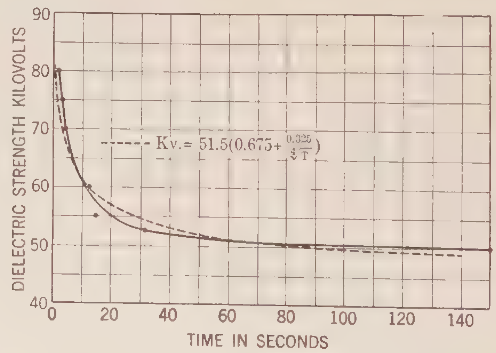


FIG. 4—60-CYCLE STRENGTH CURVE

One layer of 0.0935-in. oil-treated pressboard in oil at 75 deg. cent. Each point average of 10 tests. 2-in. diam. electrodes, time for voltage to build up (approx. 1 sec.) included.

varnished cambric in 25 deg. oil. These test points check the average value of a. Figs. 7 and 8 show the results of tests made on different numbers of layers of black varnished cambric in 30 deg. and 85 deg. cent. oil for longer periods of time than shown in Fig. 5. These curves also check average value of a fairly well from approximately one minute to about two hours.

(Sufficient tests were not made at this time, namely in 1915, for these latter curves to be of much value up to approximately one minute of time.) Apparently temperature of the oil has very little effect on the shape

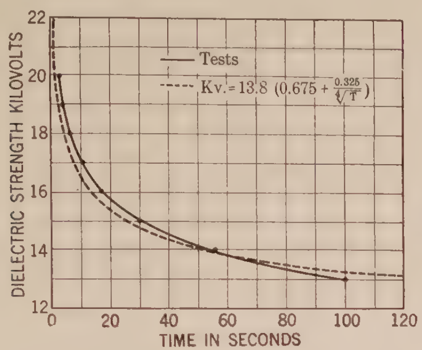


FIG. 5—STRENGTH-TIME CURVE OF 3-MIL BLACK VARNISHED BOND PAPER

Total thickness per layer 5 mils. 2 layers under No. 10 transil oil at room temperature. 2-in. electrodes. Each point average of 10 tests at 60 cycles. Time for voltage to build up (approx. 1 sec.) included.

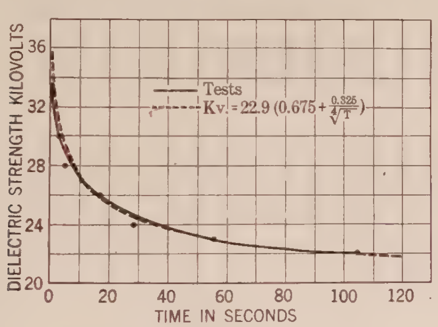


FIG. 6—60-CYCLE STRENGTH-TIME CURVE

0.012-in. black varnished cambric, 2 layers under oil at room temperature, 2-in. diam. electrodes, each point average of 10 tests, time for voltage to build up (approx. 1 sec.) included.

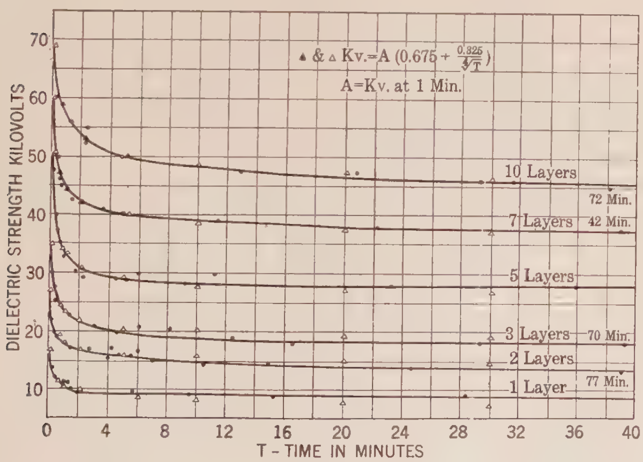


FIG. 7—60-CYCLE STRENGTH-TIME CURVES OF 0.012-IN. BLACK VARNISHED CAMBRIC

of the strength-time curves of black varnished cambric.

b. Creepage over Solid Insulation.—The 60-cycle data on creepage is discussed along with the 420 cycle creepage data under section 5 b.

c. Rupture of Oil.—Oil alone is so erratic that no very definite strength-time curve can be obtained. However, the average of a large number of tests show that the strength decreases quite rapidly after the first few seconds of voltage applications and after this the effect becomes less and probably disappears after two or three minutes time.

Fig. 9 gives the results of time tests made on No. 10

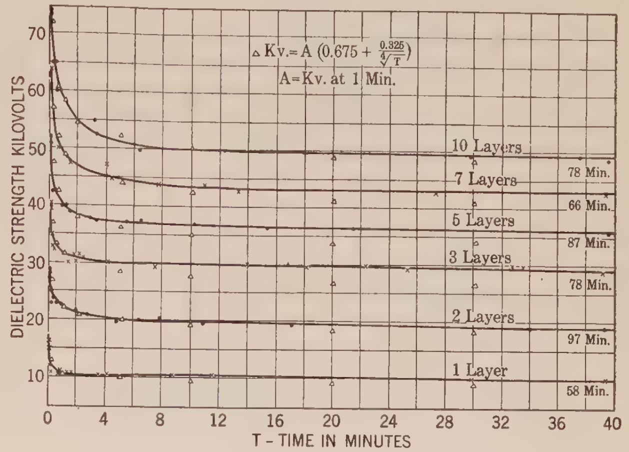


FIG. 8—60-CYCLE STRENGTH-TIME CURVES OF 0.012-IN. BLACK VARNISHED CAMBRIC

transil oil in which was submerged two 4-in. (10-cm.) round edged electrodes spaced 0.375 in. apart. The voltage was applied by closing the field switch of the generator. The scattered points illustrate well the erratic nature of oil as has already been pointed out by Hayden and Eddy.[2] (However when used in series

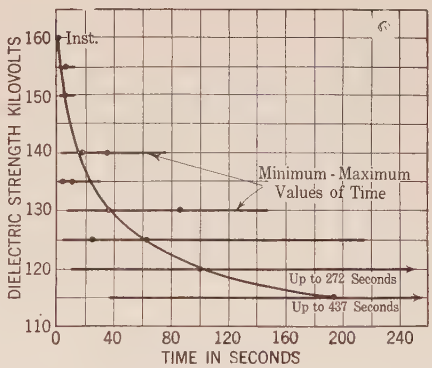


FIG. 9—STRENGTH-TIME TESTS MADE ON NO. 10 TRANSIL OIL AT 25 DEG. CENT.

Two 4-in. (10 cm.) diam. round edge electrodes spaced 0.375 in. (0.95 cm.) apart. Time for voltage to build up (approx. 1 sec.) included, each point average of 10 tests. Dielectric strength of oil 26 kv. tested with 1-in. disks, 1 in. apart.

with barriers of solid insulation, oil is one of our most reliable insulating materials).

The data shown in Table III is interesting in that it shows the effect of increasing the applied voltage. The *one second tests* were made by closing the

2. Three Thousand Tests on the Dielectric Strength of Oil," Hayden and Eddy, TRANS. A. I. E. E., Vol. XLI, 1922, p. 394.

generator field switch and holding it for approximately 1.5 seconds. The other tests were made by bringing up the voltage by means of the rheostats in the field. To make sure that the conditions were the same for each period of time, the tests were alternated with time, that is, each one-second test was followed by a rapidly applied and standard one-minute tests respectively. This was repeated until the series was completed. In each case (except the first column) the voltage was started at approximately 50 per cent of the breakdown value. For the one second tests (1st column) the voltage was started from 25 to 30 kv. less than the failure voltage, and increased in 5 kv. steps, but with rest periods between each step.

TABLE III.

EFFECT OF TIME OF VOLTAGE APPLICATION ON RUPTURE STRENGTH OF NO. 10 TRANSIL OIL

Sine wave, 60-cycle voltage—distance between 4-in. electrodes 0.375 inches. Dielectric strength of oil 25 to 30 kv. tested with one inch disks 0.1 in. apart

Duration Full Voltage Approx. one second	Voltage Increased 10 to 15 kv. per second	Voltage Increased one kv. per 5 seconds
165	164	119
165	144	109
155	170	134
150	132	136
160	168	125
150	166	135
170	174	117
160	170	94
165	165	133
170	172	140
165	150	137
135	140	110
172	168	128
165	162	130
170	158	123
167	170	141
Average 163 kv.	160 kv.	125 kv.
Per cent 130	128	100

At this point the dielectric strength of the oil was unavoidably lowered with sand to put out a fire.

120	108	78
110	122	89
118	88	86
100	110	92
125	98	80
130	118	83
125	95	91
110	100	92
95	138	97
140	145	96
134	118	108
110	138	94
Average 126 kv.	115 kv.	99 kv.
Per cent 127.5	116.5	100

The above shows that the short-time or momentary values were from 27.5 to 30 per cent greater than the approximate one-minute values, shown in last column. This is in fair agreement with the difference shown in Fig. 9 between the instantaneous and one minute values. Just why the strength should be 25 to 30 per cent higher for one second than for one minute duration of voltage is not fully known. One possible explanation is that it requires *time* for whatever impurities are present to fill up and bridge the gap. If the oil was absolutely pure it might be found that time of voltage application would have no effect on the rupture voltage. But commercial oils however are seldom, if ever, free from small particles of lint, etc., floating around.

d. Puncture of Solid Insulation and Oil in Series. The 60-cycle strength-time curves are given and discussed with the 420-cycle curves under section 5 d.

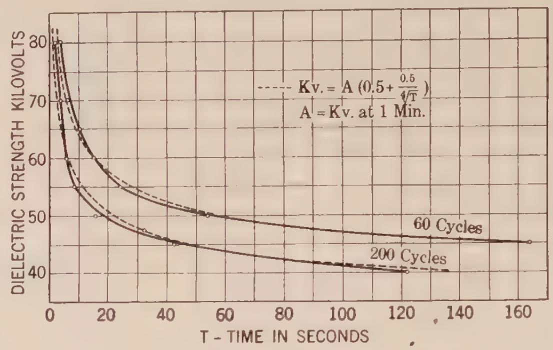


FIG. 10—60 AND 200-CYCLE STRENGTH-TIME CURVES

One layer 0.0935-in. oil-treated pressboard, in oil at 25 deg. cent. Two 4-in. (10 cm.) diam. electrodes. Each point average of 10 tests. Time for voltage to build up (approx. in 1 sec.) included

EFFECT OF FREQUENCY ON:

a. Strength-Time Curves of Solid Insulation. Up to the present we have discussed tests at only one frequency. Fig. 10 shows curves made at 60 and 200 cycles on single layer samples of 3/32 in. oil treated pressboard in oil at 25 deg. cent. The curves show

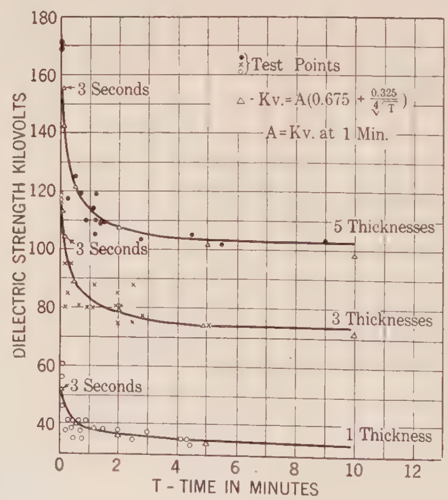


FIG. 11—60-CYCLE STRENGTH-TIME CURVES

0.0935-in. oil-treated pressboard, in oil at 100 deg. cent. two 4-in. (10 cm.) diam. electrodes, each test shown. Time shown from inst. voltage (rapidly applied) became constant until failure

approximately the same percentage difference in kilovolt values. This is an interesting fact even though it may not be known just why it is so. Perhaps some day it can be explained when the mechanism of insulation failure is fully understood.

Figs. 11 and 12 show strength-time curves made on

various numbers of layers 3/32-in. pressboard at 60 and 420 cycles.

To prevent absorption of moisture, the material was immersed under oil immediately after vacuum treatment and removed only as needed for test. The voltage for this series of tests was raised as rapidly as possible by the rheostats in the field circuit of the generator. The time shown on the curves is that which elapsed from the time the voltage reached a steady value and held at this value until break-down. The r. m. s. values of the peak values determined by spark gap were used in plotting the curves. Each test point is shown.

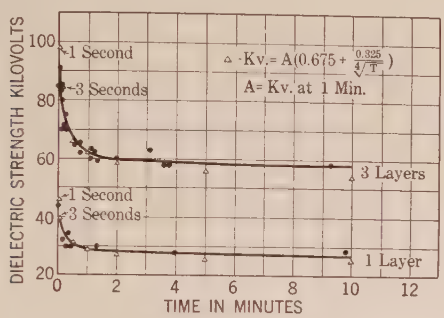


Fig. 12—420-Cycle Strength-Time Curves

0.0935-in. oil-treated pressboard, in oil at 100 deg. cent. Two 4-in. (10 cm.) diam. electrodes, each test shown, time shown from inst. voltage (rapidly applied) became constant until failure

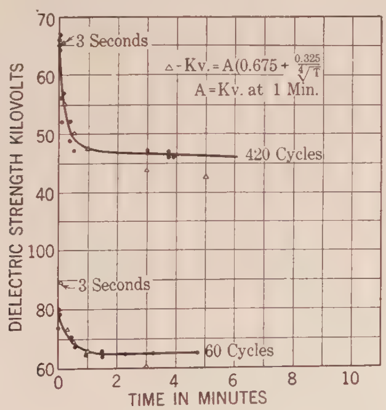


Fig. 13—60 and 420-Cycle Strength-Time Curves

7 layers 0.012-in. black varnished cambric, in oil at 100 deg. cent.

It will be noted that these curves are of approximately the same shape for both frequencies and check fairly closely the average value of a in equation (**2**). It is interesting to note that the 420 cycle points are not so scattered as the 60-cycle points. This seemed to be characteristic of all tests made at the higher frequencies on all insulations except oil without any barriers. Fig. 13 shows the results of tests made on black varnished cambric at 60 and 420 cycles. These curves show that the 420-cycle strength is approximately 75 per cent of the 60-cycle strength.

Fig. 14 gives the results of one and fifteen minute tests made at 60 and 420 cycles on various thicknesses of pressboard. These curves show that the 420-cycle values are approximately 75 per cent of the 60-cycle values for all thicknesses tested.

b. Variation of Dielectric Strength of Solid Insulation for any Given Time. Table IV gives a summary of the 420-cycle dielectric strength expressed as a percentage of the 60-cycle strength.

TABLE IV.
SUMMARY OF 420-CYCLE DIELECTRIC STRENGTH IN PER CENT OF 60-CYCLE STRENGTH

Time				Material	Shown in Fig.	Remarks
Momentary	1 min.	5 min.	15 min.			
76	80	80	..	3/32-in. P.B.	12	1 layer
76	75	78	..	3/32-in. P.B.	12	3 layers
82	72	71	..	0.012-in. B.V.C.	13	7 layers
not observed	72.5	not observed	70	1/32-in. P.B.	14	Average of 2 to 8 layers
..	71.0	..	..	3/32-in. P.B.	14	Average of 1 to 3 layers

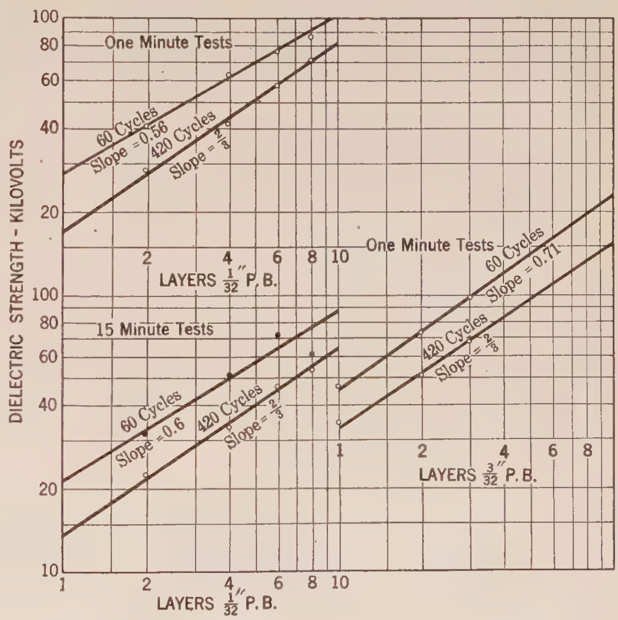


Fig. 14—Effect of Frequency and Thickness on Dielectric Strength of Pressboard at 25 Deg. Cent.

4-in. (10 cm.) diam. electrodes

While the general average of the 420-cycle kilovolt values for solid insulation is approximately 75 per cent of the 60-cycle values it will be noted that the tendency is toward a little higher percentage for momentary values. However for practical purposes it appears that we can say that the percentage is constant regardless of time of voltage application.

The determination of the relation between the dielectric strength of solid insulation at 60 and 420 cycles, does not give the effect of other near and intermediate frequencies. To determine this, a large number of tests were made at 25, 60, 200 and 420 cycles, on solid insulation under as nearly as possible the same conditions. It was found that for all these frequencies at both 25 and 50 deg. cent. the dielectric

strength can be expressed by an exponential equation of the form kv. $= K'/F^n$ where K' is a constant, F is the frequency and n is a numerical value. For 60, 200 and 420 cycles at 100 deg. cent. an equation of the same form holds, but for 25 cycles at 100 deg. cent. the values were approximately 35 per cent higher than the 60-cycle values, whereas to fall in line they should be only 12 to 15 per cent higher. At first it was thought that this departure from the equation might be due to an error into tests, but check tests showed that it was correct. These tests are given in Table V.

TABLE V.
EFFECT OF FREQUENCY ON DIELECTRIC STRENGTH OF 3/32-IN. OIL-TREATED PRESSBOARD—10-CM. ELECTRODES—VOLTAGE INCREASED UNIFORMLY AT RATE OF 1 KV. PER 5 SECONDS—IN OIL

Layers	Freq.	No. Shots	Temp. deg. Cent.	Kv. by Vm. Coil Min.	Max.	Avg.	Avg. by Spark Gap	Ratio of kv. to 60-cyc. kv.*
5	60	5	100	121	132	122.4	129	
3	60	10	100	90	94	92.	94	
1	60	10	100	50	55	52.5	54	
1	25	17	99	60	82	68.3	72	1.33
3	25	16	99.5	117	144	126.4	127	1.35
(ck)3	25	10	99	120	138	126	126.5	1.345
3	25	10	27	104	117	109.4	110	1.11
3	60	10	26	73	101	97	99	
1	420	10	100	40	45	42	41	0.76
3	420	10	100	72	76	75	73.5	0.78
3	420	6	27	76	80	78	76	0.77
1	200	11	98	36	41	39	43	0.80
3	200	10	100	70	74	72	80	0.85
(ck)1	200	4	100	41	43	42	46	0.85
(ck)3	200	4	99	78	80	79	87	0.925
5	200	3	100	96	98	97	108.5	0.84

* For same number of layers.

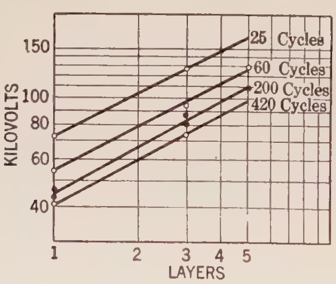


FIG. 15

Effect of frequency of dielectric strength of 3/32-in. oil-treated pressboard in oil at 100 deg. cent. Voltage increased at rate of 1 kv. per 5 seconds. 4-in. diam. electrodes.

The kv. values shown in Table V are plotted vs. layers of pressboard on double logarithmic paper in Fig. 15. When these values (expressed as a ratio of 60-cycle values) are again plotted against the reciprocal of the frequency it will be seen, Fig. 16, that except for the 25-cycle point around 100 deg. cent. they all fall in a straight line.

For practical purposes we can neglect the 25-cycle points at 75 deg. and 100 deg. (since we are concerned here only with frequencies ranging from 60 to about 500 cycles) and use an equation derived from the straight line.

The equation of dielectric strength vs. frequency, or of the line in Fig. 16, is:

$$E = 1.75/F^{0.137} \qquad (3)$$

where E is, for any given time, the ratio of strength to 60-cycle strength and F is the frequency in cycles per second.

Although no claim is made for accuracy beyond about 500 cycles it is interesting to note that this

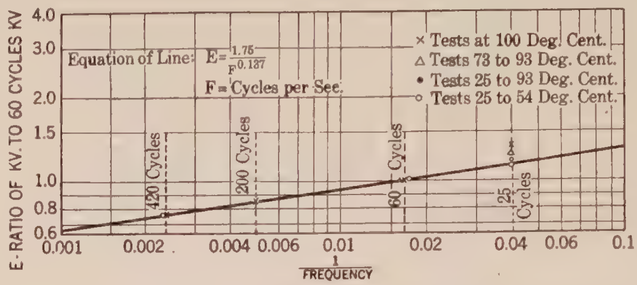


FIG. 16—EFFECT OF FREQUENCY ON RATIO OF DIELECTRIC STRENGTH OF SOLID INSULATION

method of calculation holds fairly closely in comparing Peek's results of tests made at 60 and 90,000 cycles as shown in Table VI.

TABLE VI.
DIELECTRIC STRENGTH AT 60 AND 90,000 CYCLES—FROM F. W. PEEK, PAGE 184, HIGH VOLTAGE ENGINEERING
OILED PRESSBOARD

Time	60 Cyc. test kv.	90,000 cyc. test kv.	90,000 cyc. kv. values calculated by equa. (3) from 60-cyc. test
inst.	35.5	9.5	13
inst.	39.5	6.1	14.4
one min.	31	7.3	11.3
	37	4.1	13.5
VARNISHED CAMBRIC			
inst.	53	19.5	19.4
inst.	42	13.5	15.3
inst.	42	10	15.3
one min.	46.5	17.8	17
	31	10	11.3
	31	7.5	11.3

b. Creepage Over Solid Insulation. Tests made with the electrodes on the same side of the sample piece, *i. e.* when the solid insulation was under no stress, gave very erratic results, corresponding more nearly to those obtained on rupture voltage of oil alone. Neither time nor frequency seemed to have any material effect on the failure voltage. But when the electrodes were placed on opposite sides of the test sample (that is when the material was under a stress) frequency had approximately the same effect on the arcover voltage as it had on the puncture voltage, *i. e.* the 420-cycle strength was approximately 75 per cent of the 60-cycle strength. As shown by the data given in Figs. 17 and 18, *time* had very little effect at either frequency.

c. Rupture Voltage of Oil at 60 *and* 420 *Cycles.* While it was not expected that the dielectric strength of transformer oil would vary with such a small difference in frequency as 60 and 420 cycles, tests were made using 4-in. (10 cm.) round edged electrodes spaced 0.375 in. apart in oil that tested 27 kv. with standard 1-in. electrodes spaced 0.1 in. apart. The voltage was increased at the rate of 1 kv. per 5 seconds. The results of these tests are shown in Table VII.

TABLE VII.

60- AND 420-CYCLE RUPTURE VOLTAGE OF NO. 10 TRANSIL OIL

Number of shots at each frequency 25. Temp. of oil 28 deg. cent.

Frequency	Kv. by Vm. Coil			Kv. by
	min.	Max.	Avg.	Spark Gap
60 cycles	86	117	97	98
420 cycles	80	130	106.8	99

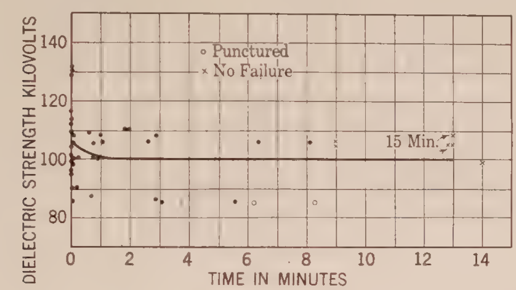


FIG. 17

60-cycle creepage tests on oil-treated, 0.0935-in. pressboard, in oil at 100 deg. cent. 4-in. diam. electrodes on opposite sides of barrier of 5 layers of pressboard. Total creepage distance 1.47-in. approx. stress on insulation 235 volts at 110 kv.

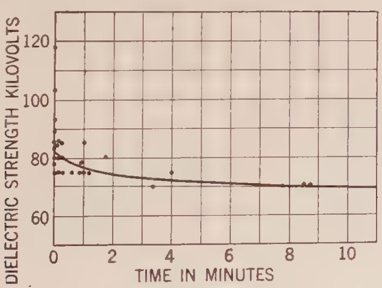


FIG. 18

420-cycle creepage tests on 0.0935-in. oil-treated pressboard, in oil at 100 deg. cent. 4-in. diam. electrodes on opposite sides of barrier of 5 layers of pressboard. Total creepage distance 1.47-in. (approx.). Stress on insulation 171 volts per mil at 80 kv.

Apparently frequency within the limits of 60 and 420 cycles has a negligible effect on the strength of oil.

d. Strength-Time Curves of Solid Insulation and Oil in Series. Referring to Figs. 19 and 20 it will be seen that the 60- and 420-cycle curves are of approximately the same shape as those (Figs. 11 and 12) for solid insulation, that is, they check the average value of a in equation (**2**). The oil duct was equal to the thickness of the pressboard sheets.

But when the oil duct is three times the thickness of the pressboard sheets, the strength-time curve taken at 25 deg. cent. Fig. 21 departs somewhat from the curve taken on solid pressboard at 25 deg. cent. (which we have seen checked the minimum value of a) and agrees more nearly with the average value of a up to about one minute. After one minute the curve apparently flattens out like the one for oil without barriers.

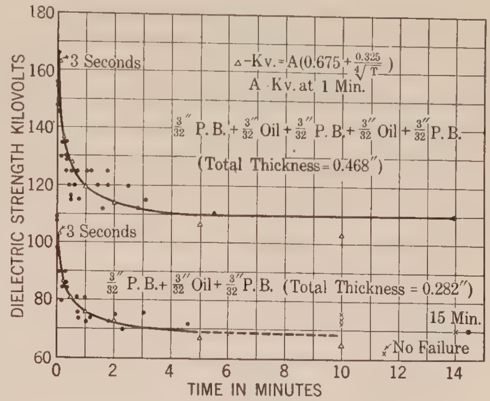


FIG. 19

60-cycle strength-time curves of oil-treated pressboard and oil in series at 100 deg. cent. oil ducts bridged by pressboard spacers. Time shown from inst. voltage (rapidly applied) became constant until failure, 4-in. diam. electrodes.

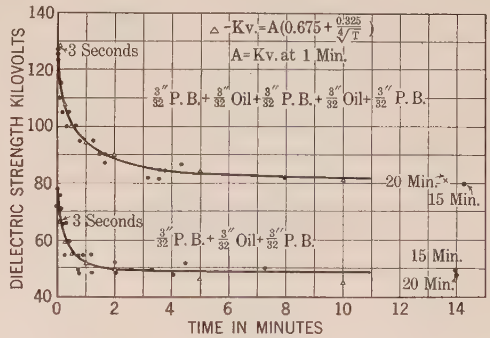


FIG. 20

420-cycle strength-time curves of oil-treated pressboard and oil in series at 100 deg. cent. Oil ducts bridged by pressboard spacers. Time shown from inst. voltage (rapidly applied) became constant until failure, 4-in. diam. electrodes

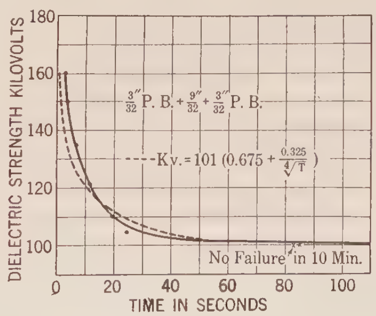


FIG. 21

60-cycle strength-time curve of solid insulation and oil in series at 25 deg. cent. Average of 10 tests, 4-in. diam. electrodes, time for voltage to build up (approx. 1 sec.) included. Material 3/32-in. oil-treated pressboard.

This is, as will be shown later, the worst condition to meet, *i. e.,* it requires the least reduction in time at the higher frequencies to make the strain equal to a 60-cycle test for one minute.

e. Variation of Dielectric Strength of Solid Insulation and Oil in Series for any Given Time. Table VIII gives the results of tests made at 60 and 420 cycles on four different combinations of oil and pressboard in series.

TABLE VIII.

DIELECTRIC STRENGTH OF PRESSBOARD AND OIL IN SERIES 4 IN. (10 CM.) DIAM. ELECTRODES. VOLTAGE INCREASED UNIFORMLY 10 KV. PER MINUTE FROM 55 KV. EXCEPT IN FIRST CASE

(Values taken from Strength-Time Curves Figs. 19 and 20), Each Value Average of 10 Tests.

Case No.	Thickness of Pressboard Sheet*	Oil Duct	60-cycle Kv.	420-cycle Kv.	Ratio: 420 cyc. kv. 60 cyc. kv.
1	3/32 in.	3/32 in.	76	52	0.75
			120	95	
2	3/32 in.	3/16 in.	111.7	98.1	0.88
3	3/32 in.	9/32 in.	125.6	113.6	0.903
4	3/32 in.	3/8 in.	129.8	117.3	0.903

*Adjacent to each electrode

Assuming that the dielectric strength of solid insulation and oil in series is a function of the reciprocal of the frequency (the same as for solid insulation) the

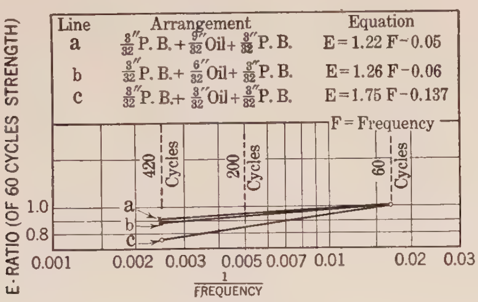


FIG. 22

Effect of oil in series with solid insulation on ratio of dielectric strength at different frequencies, 4-in. (10 cm.) diam. elec. points taken from data in Table 9.

results shown in Table IX and plotted as shown in Fig. 22 enable us to find the effect of frequency between the limits of 60 and 420 cycles on different arrangements of solid insulation and oil in series.

The equations for these conditions are as follows:

Arrangement	Equation
3/32 in. P. B. + 3/32 in. oil + 3/32 in. P. B.	$E = 1.75\ F^{-137}$
3/32 in. P. B. + 3/16 in. oil + 3/32 in. P. B.	$E = 1.26\ F^{-.06}$
3/32 in. P. B. + 9/32 in. oil + 3/32 in. P. B.	$E = 1.22\ F^{-.05}$
3/32 in. P. B. + 3/8 in. oil + 3/32 in. P. B.	$E = 1.22\ F^{-.05}$

Relation Between Time Frequency and Dielectric Strength of Transformers

The question that naturally presents itself is: What condition shall we take to base the *time* on for various frequencies used in making induced potential tests?

The two extreme conditions are (1) oil alone which requires the same length of time no matter what frequency is used and (2) creepage over solid insulation which is under a fairly high voltage stress, *i. e.* with the electrodes on opposite sides of the barrier and where *time* had a small effect but the strength decreased with an increase in frequency. This condition would really require that the test voltage be reduced for the higher frequency even though the time be reduced. But the test voltage could not be reduced even if the time be kept the same because the test would not disclose any weak points in the oil distances.

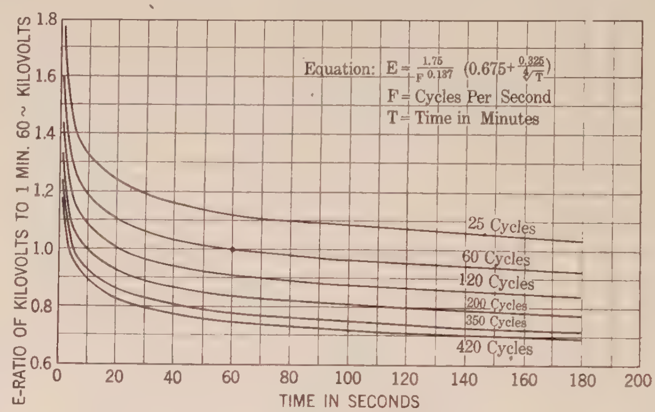


FIG. 23

Effect of frequency and time of voltage application on dielectric strength of solid insulation and solid insulation and oil in series (having equal parts of oil and pressboard) temperature 75 to 100 deg. cent.

General average conditions of either all solid insulation or of solid insulation and oil in series should be a fair basis for estimating the *time* of test.

If equation (1) which gives the variation in dielectric strength with time is multiplied by the equation ($E = k / F^n$) giving the variations of strength with frequency the resulting general equation is

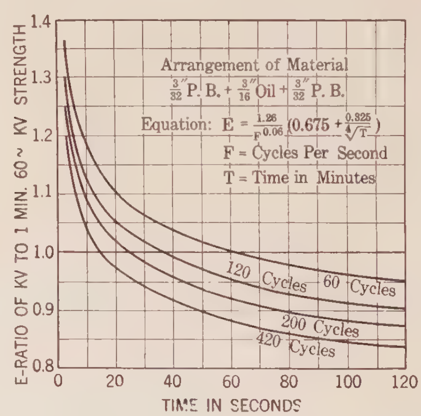


FIG. 24

Effect of frequency and time of voltage application on dielectric strength of pressboard and oil in series at 25 deg. cent.

$$E = k/F^n\left(a + \frac{1-a}{\sqrt[4]{T}}\right) \qquad (4)$$

Fig. 23 shows a series of curves plotted from equation (4) giving the relation between *time, frequency* anp *ratio of dielectric strength* for the average solid insulating materials and for a combination of solid

insulation and oil in series where the oil distance is equal to the thickness of solid insulation.

The curves shown in Fig. 24 are similar to those in Fig. 23 excepting that they are for the conditions where the oil duct is double the thickness of the press board pieces.

Expressed in seconds equation (4) becomes

$$t = \left[\frac{\dfrac{(1 - a)}{E\, F^{n}}}{k} - a \right]^{4} 60 \qquad (5)$$

in which t is time in seconds, F is frequency in cycles per second, a and k are constants, n a numerical value depending on the material and arrangement of material and E is the ratio of dielectric strength, equal to unity when comparing with 60-cycle strength for one minute.

Table IX gives the relation between time and frequencies to produce the same voltage strain at 60, 200, 350 and 420 cycles.

TABLE IX.

TABULATION OF MATERIAL, TEMPERATURE, CONSTANTS AND TIME TO PRODUCE APPROXIMATELY THE SAME VOLTAGE STRAIN AT DIFFERENT FREQUENCIES—TIME CALCULATED BY EQUATION (5) ASSUMING $E = 1$

Material and Arrangement	Temp. deg. cent.	Value of Constants used in equa. (5)			Time in Seconds (Approx.) cycles			
		a	k	n	60	200	350	420
(1) Solid press board......	25	0.5	1.75	0.137	60	18	11	9.0
(2) Solid press board......	75–100	0.675	1.75	0.137	60	11	6	4
(3) Equal Dist. of P.B. and Oil..................	75–100	0.675	1.75	0.137	60	11	6	4
(4) Two 3/32 in. P.B. barriers separated by one 3/16 in. oil duct........	25	0.675	1.26	0.06	60	26	17	15
(5) Two 3/32 in. P.B. barriers separated by one 9/32 in. oil duct.........	25	0.675	1.22	0.05	60	29	21	19

If we choose the constants for the arrangement of material, etc. as shown in case (5) of Table IX which condition requires the least reduction in *time*, the tabulation in Table X gives the duration of equivalent induced voltage test at various frequencies as estimated by equation (5).

TABLE X.

DURATION OF EQUIVALENT INDUCED VOLTAGE TESTS AT VARIOUS FREQUENCIES

Frequency cycles per sec.	Time of Voltage Application in Seconds
60	60
120	38
200	29
208 (3.46 × 60)	28
300	23
350	21
420	19

7. Conclusions

It is evident from the data in tables IX and X that recognition should be taken of the fact that induced potential tests when made at, say, more than double normal frequency, are far more severe that the requirements. In fact it is highly desirable that the *time* be reduced when making tests on large and expensive apparatus at considerably higher than normal frequencies, otherwise the insulation must be increased thus making it unnecessarily expensive.

8. Acknowledgements

It is desired to acknowledge the valuable assistance rendered in the Testing Department by Messrs. N. M. Albert, H. L. Garver, C. F. Green, L. D. Martin and W. F. Weikel in carrying on the long and tedious tests covering a period of three to four months.

EXPERIMENTS WITH TELEPHONE DIAPHRAGMS

It is well known that when the receiver of a telephone circuit is placed face to face with the transmitting microphone, continuous oscillation may be set up, and the telephone "howls," *i. e,* a continuous note of definite pitch is heard. Experiments suggested by this phenomenon have been carried out by Prof. J. T. MacGregor-Morris and Prof. E. Mallett, and are recorded in the *Journal of the Institution of Electrical Engineers.*

The effect was intensified very much by the employment of an amplifying valve circuit, and the extended phenomenon showed some curious results. As the receiver was gradually withdrawn from the microphone the pitch of the note fell and its intensity decreased. There followed a sudden rise in pitch, which again fell as the distance increased. There was one note of a particular pitch which had maximum intensity. The whole cycle could be repeated many times with the use of sufficient amplification—with two-stage amplification as many as eighteen recurrences were observed. The phenomenon is capable of a simple explanation, being caused by phase differences in the vibrations, introduced by electrical conditions of the circuit. The effect was used to measure the velocity of sound, with reasonably concordant results.

It was established that the characteristic pitch was higher than the known natural frequency of the diaphragms used. This led to the conclusion that the diaphragm might be vibrating in a higher node, and this was found to be the case; the presence of one nodal circle accounted mathematically for the observed increase in pitch, and this was confirmed by actual experiment with sand figures upon the diaphragm itself.

Whilst making no pretense at completeness, the results of these experiments are quite stimulating—they indicate new avenues of approach for experimental work upon the telephonic transmission of music, and the productions of diaphragms having more complicated modes of vibration.—*World Power.*

A Scheme for Measuring Voltage Peaks

BY RALPH D. MERSHON
Fellow, A. I. E. E.
Consulting Engineer, New York.

SOME time ago, some of my work called for the accurate measurement of the peak value of voltage waves. The existing schemes for such measurement, based on a rectifier charging a condenser, did not strongly commend themselves for my purposes. Finally, I devised a scheme for measuring voltage peaks that requires only standard apparatus that is easily portable, and that can be carried to any degree of accuracy desired, without especially skillful handling. It can be applied to any periodic voltage, pulsating or alternating. As it is a zero method, it can be used where a method requiring flow of current would introduce serious error.

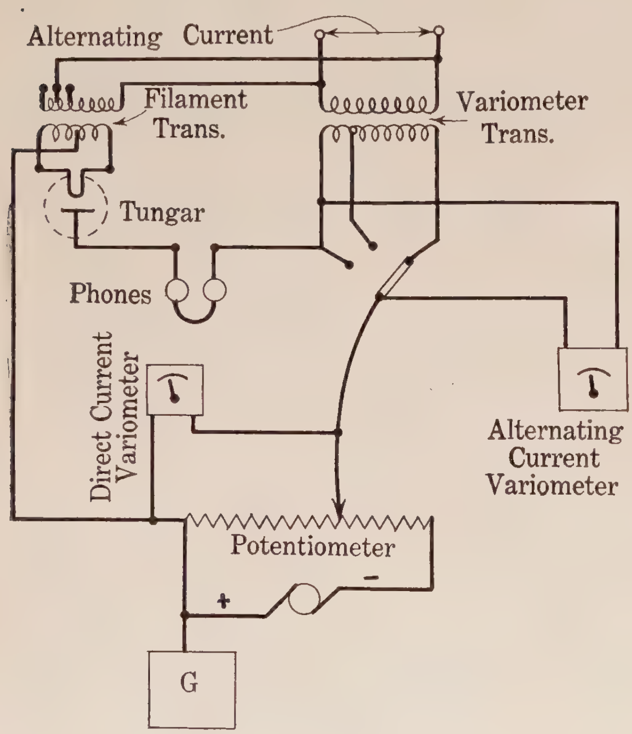


Fig. 1

It consists in using a rectifying tube to rectify the voltage (or a known fraction thereof) whose peak is to be measured, and balancing the rectified voltage against a d-c. voltage using a telephone to indicate a balance.

The embodiment of the scheme, as applied to alternating voltages, is shown in the accompanying diagrams. Referring to Fig. 1, the method of operation is similar to that of any potentiometer scheme of measurement, except that, whereas in the case of the usual potentiometer scheme an indication of unbalance is had on each side of the balancing point, in this case there is an indication of unbalance only when the balancing direct current is *less* than the peak to be measured. When starting to take a reading, it is well to apply the d-c. voltage to the circuit before applying the a-c.; and to set the potentiometer for a d-c. voltage considerably in excess of the estimated value of the peak to be measured. The potentiometer voltage will then control, and since the Tungar will not pass current in the direction of the potentiometer voltage, there will be no danger of subjecting the telephones to an excessive current, when the a-c. voltage is applied. Under these conditions, there should be no sound in the telephones. After applying the a-c. voltage, there should still be no sound in the telephones until the d-c. voltage has been diminished to a point where the a-c. voltage wave "spills over" the d-c., giving the characteristic a-c. tone. The position of the slider is then adjusted so that silence is just attained, and at that instant the voltmeters are simultaneously read. Two sets of readings should be thus taken one for one value of the a-c. voltage, and the other for, say, one fourth of that value. The quotient, obtained by dividing the difference between the two d-c. voltmeter readings by the difference between the two a-c. voltmeter readings, is the ratio of the peak to the root mean square voltage.

The reason two sets of readings must be taken is that there is a zero correction to be dealt with. If the single pole switch on the transformer secondary be thrown to the position where no a-c. voltage is included in the measuring circuit, it will be found that, with the potentiometer set for zero d-c. voltage, the telephones indicate a "spill-over" somewhat similar to that previously mentioned, and that a definite setting of the potentiometer is required for silence. For the apparatus I use, the value of the d-c. voltage required for silence—*i. e.*, the zero correction—is 2.9 volts. One of the two sets of readings mentioned above may be that for zero a-c. voltage from the transformer; that is, it may be the zero correction. But the setting for zero correction appears to be less sharp than that when an a-c. voltage from the transformer is included in the measuring circuit. The zero correction may be eliminated by introducing into the circuit a permanent d-c. voltage of a value sufficient to cut out the zero spill-over. If this is done, only one set of readings is necessary. But this expedient introduces a complication that is hardly worth while. The cause of the zero spill-over is, presumably, the stream of electrons thrown off by the filament of the Tungar—due to its temperature—independently of any voltage impressed between plate and filament. The method of differences eliminates the effect of it.

The sensitiveness of this scheme of measurement depends not only upon the sensitiveness of the tele-

phones, but also upon the magnitude of the total resistance of the circuit relative to the resistance of the telephones. It is advantageous, therefore, to keep the resistances—especially that of the potentiometer—low, relative to the resistance of the telephones. I am using a Tungar rated at 2 amperes, a set of radio phones having a resistance of 2000 ohms, and a potentiometer having a total resistance of 284 ohms. With this equipment it is easily possible, in quiet surroundings, to make settings to less than 0.2 of a volt. This setting is practically independent of the magnitude of the peak measured, so that the greater the peak, the lower the percentage error due to setting. If greater accuracy is desired, or if the surroundings are noisy, an amplifier may be used in connection with the telephones. This has been done in taking measurements in a noisy power station.

If the filament transformer secondary has no middle tap, and no balance coil or suitable resistance is available for use in parallel with the filament to get at the middle point of the filament voltage, connection may be made to the filament terminal. But in such case, two values of the peak must be obtained, one with connection to one terminal of the filament, the other with connection to the other terminal. The mean of the two values so obtained is the value to be taken. The filament voltage should be that for which the Tungar is designed, though a considerable variation appears to be permissible without resulting error.

An indicating instrument may be used, instead of a telephone, to indicate a balance, but it must be a very sensitive one to get equivalent results, as a Tungar passes a very small current for a pressure of less than 10 or 12 volts. A less sensitive instrument may be used, but in such case there will have to be added to the readings of the d-c. voltmeter the previously mentioned 10 or 12 volts, the exact amount to be added to be determined from a d-c. voltage-current curve previously taken on the Tungar employed.

A ground is shown between the filament of the Tungar and the rest of the apparatus. This ground is not absolutely necessary, but the phones are quieter with it. If there is a ground in one of the elements of the circuit,—as in case the direct current for the potentiometer is obtained from a grounded supply system—the position of that element in the circuit should be such as to bring the ground between the connection to the filament and the telephone, preferably between the filament and the rest of the apparatus, as shown. The ground should *not* be between the plate terminal and the telephone, as that connection impairs the accuracy of the scheme, mainly through making the telephone noisy.

Fig. 2 shows a modification of the scheme of Fig. 1. In Fig. 1, the a-c. voltage is kept constant, and the d-c. voltage varied. In Fig. 2, the d-c. voltage is kept constant, and the a-c. voltage varied. The former must be used when no current may be drawn from the source whose peak is to be measured. The latter may be used when current may be drawn from the source on which measurement is to be made. The latter has the advantage that, if no source of direct current suitable for use with a potentiometer, is available, a radio "B-battery" may be carried along and made use of. It has the further advantage that the voltage of the B-battery is constant, so that simultaneous reading of the two voltmeters is not necessary, and a single observer can obtain accurate results. If the open-circuit voltage of the B-battery is accurately known, and can be depended upon to remain constant, the d-c. voltmeter may be omitted. But if the B-battery cannot be so depended upon, and its voltage must be measured, the d-c. voltmeter should be left on the battery at all times while measurements are being made; otherwise, an error will be introduced, due to the

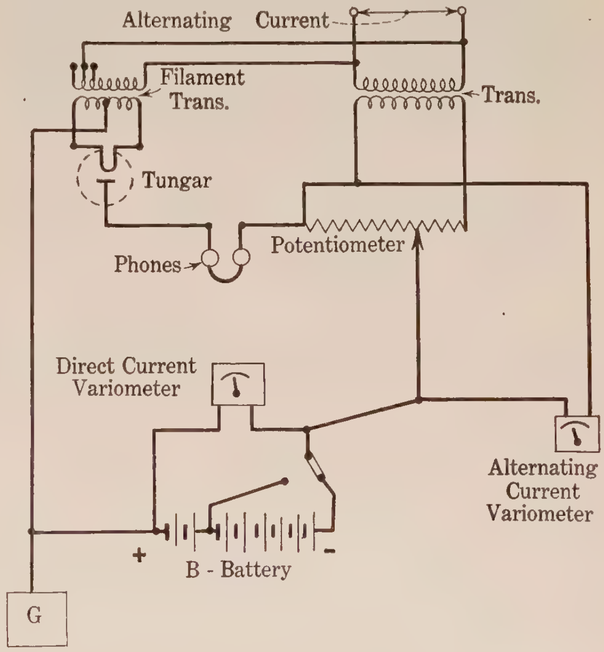


Fig. 2

internal resistance of the battery and the consequent difference in its terminal voltage when the voltmeter is on and off.

At first the endeavor was made to check up the scheme by substituting for the a-c. voltage a d-c. voltage periodically applied by opening and closing a switch. It was found that results obtained in this way were not always correct. That one could, under some circumstances, get a click in the telephone when there should be a balance. This is probably due to leakage or capacity paths between different parts of the circuit, or between them and ground. These paths may be such that on closing the switch there will be an adjustment flow of current through the telephones, even when the voltages balance each other around the path of the measuring circuit. This effect does not enter to produce any error when the scheme is used

in the regular manner. For, in that case, the circuit is opened and closed—when it is opened and closed at all—by the Tungar. And, inasmuch as an opening is an indication of lack of balance, any accentuation of the effect due to opening and closing is desirable, rather than detrimental. If a small a-c. voltage be added to the d-c. test voltage, the circuit will then be opened and closed by the Tungar, instead of by the switch, and readings taken after the manner previously described will check with those taken directly on the d-c. test voltage.

In making measurements at frequencies so high that they will not of themselves produce an audible indication in the telephone, the expedient just described should enable one to obtain accurate results. In such case, one would add to the high-frequency voltage a small voltage of audible frequency, and take measurements after the manner previously indicated.

In the case of transient voltages that are reproducible at will, it should be possible to get accurate results by alternately setting the potentiometer and producing the transient until a balance is obtained.

ILLUMINATION ITEMS

By the Lighting and Illumination Committee

FREMONT'S NEW LIGHTS SOLVE A TRAFFIC PROBLEM

The tremendous increase in inter-city passenger and truck automobile travel has brought better business to small cities situated in the line of travel. It has at the same time brought these small cities face to face with a condition of traffic and crime hazard which was not even thought of when street lighting plans were being formulated a few years ago. There is not only a general increase in local traffic over the whole city, but also a cumulative concentration of traffic on main thoroughfares resulting from inter-city traffic. Some of these highways now carry much more traffic than important streets in large cities. Unfortunately, also, with this traffic there has come the entry of reckless criminal elements from nearby large cities. Thus the small lamps and wide spacings of street lighting systems which were once considered sufficient for towns and smaller cities are now totally inadequate; in fact, the street lighting requirements on the principal thoroughfares in these towns are practically as exacting as those of the big cities.

Fremont, Ohio, a city of 12,500 people, has been one of the first of the smaller cities to grasp the seriousness of this changed condition of traffic and to visualize the tremendous value of street lighting in advertising the progressiveness of the city to out-of-town users of its streets. At the expiration of the previous street lighting contract, the officials of the city determined upon a comprehensive redesign of street lighting intended to meet the following points: (1) a closer spacing of lighting units on all residential streets, which would eliminate dark shadows and create an atmosphere of safety and comfort for drivers and pedestrians, including women and children who had occasion to use the street and sidewalks after dark; (2) a bright White Way in the central business district which would attract and dispel an impression of deadness in the business district after nightfall: (3) adequate lighting for the principal thoroughfare from city limit to city limit, making this thoroughly safe and comfortable for travel.

These desires had to be satisfied in as economical fashion as possible, for Fremont, in common with most cities, was heavily burdened with other municipal expenditures. It was, therefore, not possible to provide for underground distribution except in the White Way system and the choice of equipment throughout had to be made primarily on the basis of efficiency and neatness of appearance with consideration of ornamental features a secondary matter. Considering the conditions involved, it is believed that the new system installed has resulted in street lighting which serves its purpose to a degree exceeded by few installations elsewhere.

Fig. 1—Ornamental White Way Lighting on Front Street
600-candle power (6000-lumen) gas-filled lamps are used, equipped with ornamental lighting units and pressed steel posts spaced 80-90 feet apart on each side of the street. Mounting height, 13½ feet.

The old lighting consisted of a total of 328 lamps, that is, 238 4-ampere magnetite arc lamps and 90 80-candle power incandescent lamps. This system failed even to provide lamps for all the street intersections throughout the city. The new system employs 606 gas-filled street series lamps ranging from 600 candle power to 100 candle power.

The White Way lighting of Front Street is shown in Fig. 1. Novalux fixtures mounted on 13½ ft. pressed steel standards equipped with 600-candle power, 20-ampere lamps are spaced about 80 ft. apart on each side of the street.

The main highway through the city is State Street, carrying the traffic between Detroit, Toledo and Cleve-

land. On this thoroughfare 600-candle power, 20-ampere gas-filled lamps are used in bracket Novalux units as shown. As the street is wide the lamps were placed on each side and staggered, with one lamp for approximately 150 ft. of street. Upward light on a thoroughfare of this character is of little value but bright street illumination is of the greatest importance for safety. Accordingly, the equipment selected consisted of rippled globes with refractors which direct a large proportion of the light to the street surface. The street surface appears to the eye as a sheen of nearly uniform brightness against which objects stand out sharply and distinctly. The mounting height of 20 ft. places nearby units outside the ordinary range of vision of automobile drivers and consequently even on dark, rainy nights, the light sources are not annoying from the standpoint of glare.

For the less travelled thoroughfares, 400-candle power 15-ampere lamps in rippled-globe dome-refractor units mounted on mast arms at heights of 20 to 25 ft. above the ground are used. On residential streets smaller dome-refractor fixtures without globes equipped with 250-candle power 6.6-ampere lamps are used suspended from mast arms. In alleys and for certain

Fig. 2—Ornamental Lighting Unit (Business District Lighting)

outlying districts, the ordinary radial-wave reflectors with 100-candle power lamps are employed.

Both station-type and pole-mounted movable-coil regulators feed the series circuits. Individual series two-coil transformers mounted in the base of the posts in the case of the White Way lamps and overhead at the cross arms in the case of the remainder of the system are used for supplying the 15 and 20-ampere 400 and 600-candle power lamps. These transformers avoid high voltage at the lamp fixtures and eliminate the possibility of open circuits due to breaks in the lamp loops. In order to reduce trouble from tree grounds, the small lamps in residential districts are grouped on 1 to 1 ratio transformers connected into the high-tension series circuits.

The old lighting from the 328 units provided an approximate total of 102,000 candle power at a cost to the city of about $15,500 per year. The new lighting represents an approximate total candle power of 185,000 or an increase of 80 per cent in quantity of light and an

Fig. 3—The New Lighting on State Street

A part of the main highway between Detroit, Toledo and Cleveland. 600-candle power (6000-lumen) gas-filled lamps in ornamental bracket units; staggered spacing, one lamp for each 150 feet of street. Mounting height—20 feet.

added improvement in the distribution of candle power. The annual cost under the new lighting contract is approximately $22,500, an increase of only 45 per cent. The expenditure per capita for the new street lighting is $1.80 annually. This is more than double that in the average city where adequate street lighting under the new conditions of travel has not been worked out as yet, but is a very moderate investment for the value returned. A summary of the equipment employed and the rates adopted for the Fremont installation is given below:

	Number	Size	Rate
White Way	26	600 C.P.	$60.00
Thoroughfare	67	600 C.P.	55.00
	151	400 C.P.	47.00
Residential	216	250 C.P.	32.00
Outlying and Alleys	146	100 C.P.	22.50

LIGHT CONTROLS CADENCE

Light played a novel role in the recent Knights Templar's parade at Columbus, Ohio. Signals placed in the range of the marchers' vision, and controlled by a clockwork flasher, winked 100 times per minute, giving the drummers the cue for uniform cadence among the thousands of marching knights.

JOURNAL
OF THE
American Institute
of Electrical
Engineers

PUBLISHED MONTHLY BY THE A. I. E. E.
33 West 39th Street, New York
Under the Direction of the Publication Committee

Subscription. $10.00 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippines; $10.50 to Canada and $11.00 to all other countries. Single copies $1.00. Volumes begin with the January issue.

Changes of advertising copy should reach this office by the 15th of the month for the issue of the following month.

Midwinter Convention Promises Enjoyable Visit

The Fortieth Anniversary and Midwinter Convention in Philadelphia, February 4-8, promises to be exceptionally interesting and profitable. The forty technical papers are well diversified as to subject and of a high standard of excellence. Furthermore, the enthusiasm and earnest efforts of the Philadelphia members assure that all who attend will have a very pleasant and profitable visit.

Among the many excellent papers of particular value are those on transmission, telephony, electrical machinery, elevators, research, electrophysics and measurements. A complete list of the papers was published in the January issue of the JOURNAL, page 66, and in advance programs which were sent out some time ago.

In addition to the papers there will be special features, entertainment and trips. The celebration of the Fortieth Anniversary of the Institute on February 4 will reveal some interesting reminiscences as told by some of the pioneer members. Another notable feature will be the presentation of the Edison Medal on February 4.

On February 5 two transportation meetings will be held. Operating problems will be covered in the afternoon meeting by railroad operating officials and in the evening prominent railroad officers and other noted authorities will talk on the national aspects of transportation.

For the Transportation Meeting in the Metropolitan Opera House, Tuesday evening, February 5, the following speakers and subjects are scheduled:

E. G. BUCKLAND, Vice-President, New York, New Haven and Hartford R. R.

The Place of Transportation in Civilization

FRANCIS H. SESSON, Vice-President, Guaranty Trust Co., New York.

The Credit Question in Transportation

RALPH BUDD, President, Great Northern R. R.

Transportation and the Rural Situation

H. B. THAYER, President, American Telephone and Telegraph Company.

The Public's Transportation Problem

A. J. COUNTY, Vice-President, Pennsylvania R. R.

Solid Foundations for Better and Cheaper Transportation Service

Another enjoyable feature will be the dedication on February 6 of the new Moore School of Electrical Engineering at the University of Pennsylvania where fitting arrangements have been made for the entertainment of visitors, including an exhibit of late developments from the research laboratories of several manufacturers.

A visit to the Bethlehem Steel Company and Lehigh University has been planned by the Lehigh Valley Section for Friday, February 8. Among the many trips which have been arranged, an especially profitable one will be a visit to the Pennsylvania Railroad Company's shops where ten of the most modern locomotives, steam and electric, will be on exhibition.

There are in Philadelphia many places famed in history and these will undoubtedly be visited by many of those attending the convention.

On Wednesday evening an informal entertainment will be furnished and on Thursday evening the annual dinner and dance will be held. Complete plans have been arranged for the comfort and pleasure of the ladies throughout the week. Headquarters for the convention will be the Bellevue-Stratford Hotel and requests for reservations should be sent to the hotel management.

Arrangements have been made for reduced railroad rates on the certificate plan, which requires each person to purchase a one-way ticket and to obtain from the selling agent a certificate, which upon presentation at the convention will entitle the passenger to one-half rate for the return trip by the same route, provided at least two hundred fifty of the certificates are presented at the convention. Members should advise their local ticket office when purchasing their tickets of their intention to attend the A. I. E. E. convention, and should ask for the certificate.

Planning Convention Programs

Four general Institute meetings are held during each year, namely, the June or Annual, Pacific Coast, Midwinter and Spring. During this year the midwinter will be held in Philadelphia. February 4-8; the spring meeting in Birmingham, April 7-10; the Annual meeting at Edgewater Beach Hotel in Chicago, June 24-27, and the Pacific Coast at Pasadena, October 13-16. Each year the Meetings and Papers Committee is charged with arranging the technical programs for these meetings and members may be interested in the general plan of procedure determined upon for the coming meetings.

The midwinter meeting has become noted for the presentation of a large number of technical papers, and the meeting this year bears out this reputation as over forty papers are scheduled. The Spring meeting is usually a three day meeting and accents the technical aspects of electrical engineering of greatest importance to the majority of engineers in the locality in which it it may be located. The June or Annual meeting is a resort type of convention and accents sociability and acquaintainship, while the Pacific Coast meeting is adapted to serve the needs and record the achievements of the engineers in the West, many of whom cannot attend the other meetings because of the distance and the time required for traveling.

At each of these meetings special feature programs are planned and inspection visits and entertainments are becoming increasingly elaborate, because each local convention committee takes pride in doing its utmost to please the visiting members and their families. Each local committee has charge of all features of a convention excepting the technical program, and even in this they cooperate with the Meetings and Papers Committee of the Institute.

In preparing the technical programs, plans are made a year in advance and the papers must be received ninety days previous to the meeting at which they are to be presented. The papers are obtained from three sources: (a) the technical committees of the Institute, (b) the voluntary contributions of members, (c) the outstanding papers presented at section meetings. At present about ninety per cent of the papers are obtained through the efforts of the technical committee workers.

All papers when first received are recorded at headquarters and are there assigned to one or more technical committees for scrutiny and comment. After having been returned to headquarters, the papers may be returned to authors for additions or corrections, and when approved go to the editor of the JOURNAL for printing. Advance copies of the papers are then sent to several members specializing in the technical features treated, and also to other members that may request them. In addition some of the papers or abstracts of long papers are printed in the JOURNAL in advance of the convention in so far as space permits.

Needless to say a heavy peak load comes on the editor of the JOURNAL four times a year in attempting to get a large number of papers printed in a short time, and the volume of production is now so great that the cost of printing is a very appreciable item, and should be considered by authors when writing the papers and preparing illustrations.

For instigating papers for a particular convention, the Meetings and Papers Committee in consultation with the local convention committee plans certain of the sessions very carefully and solicits the papers desired through the chairman of the technical committees. The chairman then invite papers from members who are known to have done research work along the particular lines considered. This is done readily, for the committee chairmen keep in close touch with the research work under way in their respective jurisdictions and plan for future papers very early in each year. Other papers are contributed or recommended by members, by section chairmen, or by joint committees working with other engineering groups.

This year a very definite attempt has been made to feature certain major developments at each convention. At the midwinter, transmission, elevator applications, metering and communication vie in interest and value with research papers on the electrophysics type. In addition a special feature is a group of papers on the national transportation system. At the spring meeting oil breakers and electro-metallurgy are accented and a special feature is the hydroelectric developments of the South. At the June meeting, technical committee reports, standardization and distribution will be featured while transmision and energy utilization will be accented at the Pacific Coast meeting.

At each of these meetings definite moves are made to give a national aspect to the program by having papers presented by authorities from all sections and by having discussions presented in the light of nation-wide researches and experiences. This national aspect is obtained through close cooperation of all committees and careful planning with a broad perspective.

The outline given immediately introduces to the members many of the problems which the meetings and Papers Committee face in handling convention papers. It is hoped to work out definitely a code whereby better results may be obtained in the way of balance and quality in production. For example, it is necessary to define more carefully the type of papers which is of Institute caliber or comes within the scope of its activities, and to determine how much of the economic or practise aspect can be incorporated properly in an Institute paper. Also an author's code book should be provided so that definite instructions can be made known to authors before a paper is written in order to save costs in printing, and, besides, the general method of preparing a technical paper should be outlined based upon years of experience.

Some steps can well be taken to increase the quality of papers and reduce the number by having more time for the technical committees to discuss and to digest a group of papers treating of a particular technical problem. Also a closer coordination of technical committees and research workers will insure the Institute recording all developments in the art promptly and accurately, and it is hoped to secure closer cooperation with sections so that their program committees can utilize more adequately the knowledge of the technical committee chairmen as to the best men to write or speak on those topics the sections are interested in particularly. These plans are definitely in hand and only lack of time from more direct work prevents their being carried to fruition.

Only those on the inside realize how much time and effort is expended by committee members in handling the technical features of the programs for four conventions a year and in attempting to get better committee production. And if results fall short of the ideal it is because the committeemen cannot devote all their time to Institute work. Progress is being made each year and better and better papers are being presented as is evidenced by the very large attendance at recent conventions.

Future Section Meetings

Chicago.—March 10, 1924. Subject: "The Economics of Engineering." Speaker: Professor Riggs, of the University of Michigan.

Cincinnati.—March 13, 1924. Subject: "Telephony." Speaker: Mr. H. S. Osborne, Transmission Engineer, American Telephone and Telegraph Company, New York.

Cleveland.—March 20, 1924. Subject: "Education and Development of Men for the Industry." Speaker: Professor Paul Lincoln, of Cornell University.

Columbus.—March 28, 1924. "Convention" Meeting.

Fort Wayne.—March 13, 1924. Ladies' night. Exhibition of Hosiery Knitting; Bowling and Basket Ball; at Wayne Knitting Mills, 8:00 p. m.

March 27, 1924. Subject: "Asphaltic Highway Construction" (illustrated). Speaker: Mr. George W. Craig, Manager, Middle Western Branch of The Asphalt Association; at General Electric Company Bldg., 16-2—8:00 p.m.

New York.—February 27, 1924. A joint meeting with the Metropolitan Section of the A. S. M. E. on a power subject. Program to be announced shortly.

March 19, 1924. A joint meeting with the Metropolitan Sections of A. S. M. E. and A. S. C. E. on "City Planning and Transportation."

April 16, 1924. "The Telephone Systems of Greater New York."

Philadelphia.—March 10, 1924. Subject: "The Stability of High-Voltage Transmission Lines." Speaker: C. L. Fortescue. A dinner of the local Section will be held previous to the meeting at the Engineers Club.

Pittsfield.—February 28, 1924. "Motion Pictures of the Invisible." Picture Service Corporation Lecture, illustrated with motion pictures.

Vancouver.—March 7, 1924. Subject: "Automatic Substation Operating and some Features of Power Factor Correction." Speaker: Mr. R. L. Hall.

Washington, D. C.—March 11, 1924. Subject: "Radio Developments." Speaker: Mr. R. H. Ranger, of the Radio Corporation of America. Mr. Ranger will deal with some of the more recent developments in radio communication and broadcasting methods and equipment.

Kelvin Medal Awarded to Elihu Thomson

Dr. Elihu Thomson, Past President of the Institute, has received notification from London that the Kelvin Gold Medal has been awarded to him.

The founding of the medal resulted from the movement some years ago to erect a memorial window to Lord Kelvin in Westminster Abbey. The members of many of the engineering and scientific societies throughout the world were invited to contribute to the fund for this memorial window, with the result that the amount required was over subscribed. At a meeting of the Executive Committee of the Kelvin Medal Memorial Fund held November 23, 1914, it was resolved that the surplus fund should be used for the establishment of a Kelvin Gold Medal to be awarded triennially as a mark of distinction to a person who had reached high eminence as an engineer or investigator in the kind of work applicable to the advancement of engineering with which Lord Kelvin was especially identified. This medal was first awarded in the year 1920, to Dr. William Cawthorne Unwin.

Elihu Thomson

The Committee of Award consists of the Presidents of The Institution of Civil Engineers, The Institution of Mechanical Engineers, The Institution of Electrical Engineers, The Institution of Naval Architects, The Iron and Steel Institute, The Institution of Mining and Metallurgy, The Institution of Mining Engineers, The Institution of Engineers and Shipbuilders in Scotland; and the organizations which assisted in raising the original Kelvin Fund were invited to submit nominations for the award of the Medal.

Accordingly, the four American national societies of civil, mining, mechanical, and electrical engineers were invited several months ago to submit nominations for the 1923 award; and after conference of representatives of these societies, they joined in nominating Dr. Elihu Thomson. It is therefore particularly gratifying to the members of these societies that the medal has been awarded to Dr. Thomson. Arrangements are being made to present the medal at a meeting in London, in July 1924.

Dr. Elihu Thomson was born in Manchester, England, March 29, 1853. He came to the United States at the age of five years and when thirteen years old entered the Central High School of Philadelphia, from which he was graduated in 1870.

He spent six months in an analytical laboratory in Philadelphia and then returned to the High School as assistant in the chemical department with charge of the chemical laboratory. He was made Assistant Professor of Physics and Chemistry at the High School and later full Professor in both subjects, in which position he continued until 1880, having been appointed to full professorship at the age of twenty-three. During these years Professor Thomson turned towards experiments in electricity and spent much time in carrying out numerous researches.

During the winter of 1876-77 and subsequently, he lectured on electricity at Franklin Institute, and for the first course constructed his first practical dynamo.

About that time, in conjunction with Professor Edward J. Houston, he invented the continuous centrifugal separator, a machine for the separation of fluids of different densities.

Working with Professor Houston, various tests were made in 1878 at the Franklin Institute in Philadelphia, on the properties of Dynamo-Electric machines with pioneer measurements of them; also of the Electric Arcs operated thereby, which measurements, etc. were published in the Franklin Institute *Journal* in that year. An improved electric lighting apparatus was developed, for which patents were secured in 1878 and 1879, a company having been organized in 1880 and known at first as the American Electric Company, which in 1882 became the Thomson-Houston Electric Company. The perfection of the arc lighting dynamo and arc lamp went on quite rapidly, and they were installed in many of the early lighting plants in this country and Europe. His generator was one of the first and most efficient and ingenious ones used in the early development of arc lighting. Another of his early inventions was the recording watt-hour meter. A number of other indicating instruments were also devised to suit circuits then in use.

In 1892, by consolidation with Edison interests, Thomson-Houston Company became the General Electric Company.

Dr. Thomson has been granted about 700 United States patents, among which inventions may be mentioned: three-coil armature for dynamos and motors; the constant current regulator for arc lighting dynamo; the balancing of armature reaction in dynamos by series field current; the induction motor; the art of welding metals by electricity; the magnetic blowout for switches; lightning arrestors of various forms; the constant current transformer.

In addition to these inventions in the electrical field, his work also included many developments in mechanical engineering, notably in connection with steam engines, steam turbines and internal combustion engines. It is due to Professor Thomson largely that the art of electric welding has reached its present stage of development.

He is a Fellow of the American Institute of Electrical Engineers, of which he was President 1889-1890; Honorary Member of the Institution of Electrical Engineers of Great Britain; member of the British Association for the Advancement of Science; member of the Institution of Civil Engineers of Great Britain; member of the American Philosophical Society; President of the International Electrical Congress and of the Chamber of Official Delegates thereto, St. Louis, 1904; President International Electrotechnical Commission, 1908-1911; Fellow, American Academy of Arts and Sciences; Member of the National Academy of Sciences; awarded the Grand Prix in Paris, 1889-90, for electrical inventions; decorated 1889 by the French Government Chevalier and Officer of the Legion of Honor for electrical research and inventions; Grand Prize, St. Louis, 1904, for electrical work; Rumford Medal, 1902; first Edison Medalist, A. I. E. E., 1909; Elliot Cresson Medal, John Fritz Medal, and the Hughes Medal of the Royal Society, London, 1916; Life member of the Corporation of Massachusetts Institute of Technology and its Acting President, 1920-1923; Director of the Thomson Laboratory, General Electric Company, Lynn; Member of the National Research Council.

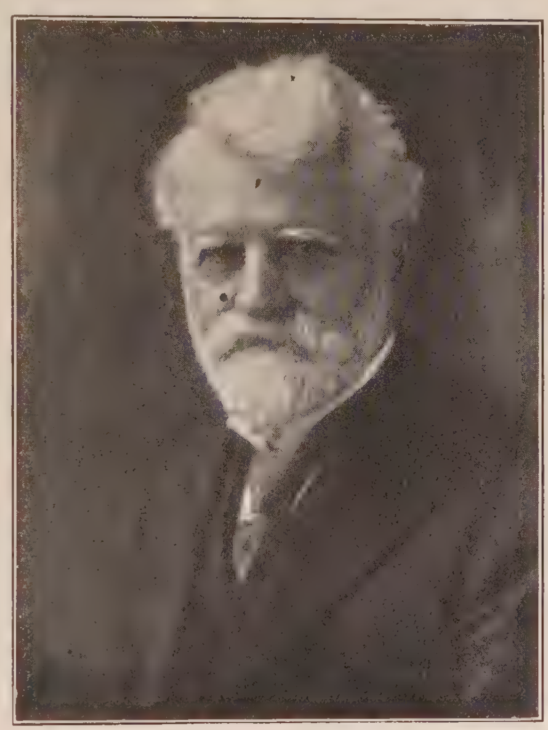
By reason of his long and productive service in the fields of electrical engineering, Elihu Thomson is generally regarded as

the Dean of Electrical Engineers in America. His work is of an international character and has advanced both the Engineering Profession and the welfare of mankind. His contributions to scientific developments are of a very broad character and embrace the fields of Electrical and Mechanical Engineering, Education, and Chemistry. As an educator his influence has been felt not only in the class room but also in the fields of practical accomplishment where his ideals and methods have been an inspiration to others. In his ability to carry a problem from the realms of theoretical hypothesis to those of practical application, the work of Elihu Thomson closely resembles that with which Lord Kelvin was closely identified.

Ambrose Swasey Awarded John Fritz Gold Medal

The 20th award of the John Fritz Gold Medal was made January 18th, to Ambrose Swasey, of Cleveland, Ohio, for the building of great telescopes, benefactions to education, founding of Engineering Foundation, and the invention and manufacture of fine machine tools, precision instruments and military and naval range finders.

This medal was established in 1902 in honor of John Fritz, one of the great pioneers in the American iron and steel industry. It is awarded annually for notable scientific or industrial achievement and is the highest honor bestowed by the engineering profession in this country.



Ambrose Swasey

Mr. Swasey is Vice-Chairman of the Board of the Warner & Swasey Company. He was one of the organizing members of the American Society of Mechanical Engineers and is a past-president and honorary member. He is also an honorary member of the American Society of Civil Engineers and of several other engineering societies of America and Europe. He is an Officer of the Legion of Honor, of France, and has been the recipient of many other honors. He is a member of the National Academy of Sciences and of the National Research Council, and a Fellow of the Royal Astronomical Society, of England.

The most notable of his many public benefactions was the establishment of Engineering Foundation as the joint research instrumentality of the four great national societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers.

Among the remarkable telescopes built by his company are the 36-inch Lick refractor at Mt. Hamilton, California, the 26-inch telescope of the Naval Observatory at Washington, the 40-inch telescope of the Yerkes Observatory at Williams Bay, Wisconsin, and the 72-inch reflecting telescope of the Dominion Astronomical Observatory at Victoria, British Columbia.

Ambrose Swasey was born at Exeter, New Hampshire, December 19, 1846, of New England lineage. He worked at the machinist's trade in Exeter, and in the Pratt & Whitney Company's shops at Hartford, Connecticut. In these early years, he met Worcester R. Warner, who became his lifelong friend and partner. About 1880, they went to Chicago, but soon concluded that Cleveland was the more suitable location for their intended business.

Mr. Swasey has been an extensive traveler and his interests have been correspondingly broad.

The John Fritz Gold Medal has heretofore been awarded to the following distinguished engineers:

John Fritz
Lord Kelvin
George Westinghouse
Alexander Graham Bell
Thomas Alva Edison
Charles T. Porter
Alfred Noble
Sir William Henry White
Robert W. Hunt
John Edson Sweet
James Douglas
Elihu Thomson
Henry Marion Howe
J. Waldo Smith
George W. Goethals
Orville Wright
Sir Robert A. Hadfield
Charles Prosper Eugene Schneider
Senator Guglielmo Marconi

Joint Conference Committee of the Four Founder Societies

The first formal meeting of the Joint Conference Committee of the Four Founder Societies was held January 21, 1924. This committee, which consists of the presidents and the secretaries of the four societies, has been appointed, in accordance with the action of the governing bodies of the four societies, as an effective means of giving preliminary consideration to various problems of joint interest, of suggesting the policy to be followed in each case, and of recommending the procedure for carrying out the policies, using as far as practicable existing agencies.

Those present were — American Society of Civil Engineers: Past Vice-President Robert Ridgway (representing President C. E. Grunsky), Secretary John H. Dunlap; American Institute of Mining and Metallurgical Engineers: President E. P. Mathewson, Secretary F. F. Sharpless; American Society of Mechanical Engineers: President F. R. Low, Secretary Calvin W. Rice; American Institute of Electrical Engineers: Past President F. B. Jewett (representing President Harris J. Ryan), Secretary F. L. Hutchinson.

In accordance with the plan agreed upon, the president and the secretary of each of the four societies will serve as chairman and secretary of the Conference Committee in order of seniority of the society, commencing with the A. S. C. E.

A letter had been received from the secretary of the Engineering Joint Council of Great Britain, from which the following is an extract:

"Our Engineering Joint Council was much interested to learn of the action recently taken in connection with cooperation between engineers in America. The problems to be faced there are similar in many respects to those which have to be dealt with in this country, and I am desired to say that the Engineering Joint Council will always be glad to be kept 'au courant' with developments in America, and to keep your Committee in touch with what is being done over here."

The secretary was authorized to transmit a letter of appreciation and to express the desire of the American committee to cooperate heartily in matters of joint interest.

Plans for the society meetings to be held in London in connection with the World Power Conference in July 1924, were discussed. Arrangements are already being made to charter one of the Cunard Line steamships, which will sail in time to reach England for the beginning of the Conference, June 30. A notable gathering of engineers is already assured, and this country is to be well represented.

The plan of His Excellency Prince Caetani, the Italian Ambassador, was explained, of bringing to this country some of the recently graduated Italian engineers, with a view of giving them some practical experience in the industrial plants and factories of this country. These young men are to begin work as simple laborers in much the same way that Prince Caetani himself began, who after graduation from the School of Mines of Columbia University, began work in the mines of the West as a laborer, keeping his identity secret.

The secretary was instructed to address a letter to Prince Caetani, stating that the Joint Conference Committee would be pleased to arrange to greet these young men on their arrival in this country.

Reference was made to the proposed Pan-American Highway Congress to be held in this country next summer.

Consideration was given to the endorsement of the project of a National Museum of Engineering and Industry as proposed by an Organizing Committee of twenty-five. Further study of the project is to be made and a report made at the next meeting of the committee.

The four secretaries were asked to present at the next meeting of the committee a proposed policy for the cooperation of Local Sections in a community with one another and with the local engineering organizations. Although there is already in action a policy of cooperation, yet it was thought advisable to reduce the policy to writing and secure general agreement to it.

Lecture on "Coordination" By Dr. Pupin

The Willard Gibbs address will be given under the auspices of the American Mathematical Society on February 29, 1924, at 8:00 p.m. in the auditorium of the Engineering Societies Building by Professor M. I. Pupin. Members of the A. I. E. E. are cordially invited to attend. The subject of the address will be "Coordination."

An unusual point in the address will be an analogy between the accomplishments of the scientist in coordinating the uncoordinated forces of nature, such as heat and electricity, for beneficial and useful ends, and the desirability of coordinating the uncoordinated forces of society, political and economical, for the improvement of the lot of mankind.

The lecturer divides all physical phenomena into two groups. First, Coordinated Phenomena, illustrated by planetary motions; second, Non-coordinated Phenomena, illustrated by molecular motions. Newton, Faraday, and Maxwell laid the broadest foundations to the dynamics of coordinated and prepared the way for the study of non-coordinated phenomena. Sadi Carnot with his second law of thermodynamics leads into dynamics of non-coordination. The discovery of the fundamental laws of radiation by Kirchoff and the development of the kinetic theory of gases by Maxwell, Boltzman and Clausius, discloses gradually the physical fact that all radiation from hot bodies is a non-coordinated process, and that by far the greatest quantities of energy in the universe are in a non-coordinated form.

Plants, animals, and particularly man cannot avail themselves of this energy except by instrumentalities of coordination. The steam engine is the earliest instrumentality invented by man for coordinating the non-coordinated energy of heat. There are instrumentalities inherent in the structure of inanimate as well as in animate bodies for coordinating the non-coordinated energies which they receive. The passage from primordial non-coordination to ultimate coordination of cosmic energies is the broadest aspect of cosmic evolution. Human society itself progresses from non-coordinated activities of individuals to the coordinated life of the organized state. Poetry, music and all the fine arts are the results of the coordinating efforts of the human spirit. But no result of these efforts is more beautiful than the character of man. The meeting will be open to all interested.

Reprints From Annual Tables

The following information has been received from the American Commissioner of the "Annual Tables of Constants and Numerical Data, Physical, Chemical, and Technological," published by an International Commission under the authority of the International Research Council and the Interntional Union of Pure and Applied Chemistry.

The Secretary-General of Annual Tables announces that the following list of reprints from Volume IV is available for sale at the prices indicated.

	Pages,	Price (Fr. francs) Paper	Bound
Spectroscopy, by M. L. Brüninghaus. Preface by A. Fowler, F. R. S.	210	35	45
Electricity, magnetism, conductivity of electrolytes, electromotive forces by MM. Malapert, v. Weisse, R. E. Slade and G. L. Higgen. Preface by F. B. Jewett	144	30	40
Radioactivity, electronics, ionization of gases, etc. by MM. J. Saphores and F. Bourion. Preface by Sir E. Rutherford, F. R. S.	19	10	18
Crystallography and mineralogy, by L. J. Spencer. Preface by Sir Henry A. Miers, F. R. S.	65	15	25
Biology, by E. Terroine and H. Colin. Preface by Jacques Loeb	37	12	20
Engineering and metallurgy, by L. Descroix. Preface by G. K. Burgess	154	30	40
Colloids, by E. Rebière. Preface by Jacques Duclaux	9	6	12

These reprints contain all of the data for the subjects indicated which are found in Volume IV of Annual Tables, which volume covers the literature of the world for the years 1913 to 1916 inclusive. Specialists having occasion to refer frequently to data in the fields covered by any of these reprints will find them invaluable for ready reference, and at the present rate of exchange the cost of these reprints is very small.

Members of any of the organizations listed below are entitled to a 50 per cent discount on the prices given above.

Orders for any of these reprints should be sent directly to Dr. Charles Marie, 9 Rue de Bagneux, Paris 6, and should be accompanied by an international money order or a draft on Paris covering the price of the reprint plus two francs for postage and packing on each order.

National Academy of Sciences
Philosophical Society of Washington
American Philosophical Society
American Academy of Arts and Sciences
American Association for the Advancement of Science
American Institute of Chemical Engineers
American Institute of Electrical Engineers
American Electrochemical Society
American Chemical Society
American Ceramic Society

American Society of Civil Engineers
American Society of Mechanical Engineers
American Society for Testing Materials
American Institute of Mining and Metallurgical Engineers

The Elwell Scholarship

Through the generous gift of Mr. Cyril F. Elwell, Stanford A. B., '07; E. E., '08, there is available in the Electrical Engineering Department of Stanford University a scholarship carrying a stipend of $500. This scholarship is designated by the authorities of the University the "Elwell Scholarship."

The purpose of the scholarship is to assist some young man of intellectual promise, but of limited means, in undertaking a year of graduate study in the Electrical Engineering Department of Stanford University. However, it is expected that the holder of the Elwell Scholarship shall come supplied with sufficient funds so that, with the assistance of the $500 stipend attached to the scholarship, he may be supported in a fair degree of comfort without being compelled, during such times as the University is in session, to do remunerative work to add to his income.

It is required that an applicant shall have gained, at least, the degree of Bachelor of Science in Electrical Engineering or its equivalent. However, applications will be considered from those who have received the degree of Bachelor of Science, or its equivalent, in Mechanical, Civil, Mining, or Chemical Engineering. For both classes of applicants, this year's work normally leads to the degree of Engineer in Electrical Engineering.

Each application should set forth as far as may be practicable the plans of the applicant relating to his proposed program of studies, and also in relation to his probable choice of work following the year at Stanford. The applicant should request several persons who are competent to judge of his character and of his intellectual ability to write directly to the undersigned in support of his application. An essential part of every application is a transcript of all the grades made by the applicant in his previous college courses. This transcript must be an original document issued and certified by the registrar (or corresponding officer) of the college concerned.

Applications must be received by April 1.

The scholarship will be awarded May 1.

All correspondence relative to this scholarship should be addressed to

Professor Harris J. Ryan, Stanford University, California

American Engineering Council

ANNUAL MEETING, WASHINGTON, JANUARY 10-11, 1924.

The annual meeting of the American Engineering Council of the Federated American Engineering Societies was held in Washington, D. C., January 10-11, 1924. About fifty delegates of the twenty-seven societies represented upon the Council were in attendance, and President Mortimer E. Cooley presided.

The representatives of the A. I. E. E. in attendance were: Calvert Townley, F. L. Hutchinson, Chas. F. Scott, C. E. Skinner, H. W. Eales and John H. Finney.

The officers elected were: President, James Hartness, Past President of the American Society of Mechanical Engineers and former Governor of Vermont. Vice-Presidents, Gardner S. Williams and L. P. Alford, to serve two years C. R. Gow to serve one year. Mr. Calvert Townley also continues to serve for another year as Vice-President. Treasurer, H. E. Howe.

A revised constitution was presented, discussed in detail, and approved. It will be voted upon by letter ballot. One of the principal changes involved is the elimination of the name "Federated American Engineering Societies" and the adoption of the name "American Engineering Council" for the organization itself, instead of for the group of representatives of the societies constituting the Federation. Both names have been used heretofore, and more or less confusion has therefore resulted. The proposed revision provides that the meetings of the representatives shall be designated as the "Assembly" of the Council, and the body by which the activities of the Council are carried on between the annual meetings is to be called the "Administrative Board."

The Indiana Engineering Society and the Engineering Society of St. Paul were added to the membership during the year 1923.

The Great Lakes—St. Lawrence River Project was discussed and the following resolution adopted:

Resolved: That it is the sense of the American Engineering Council in view of the magnitude of the project for improving the St. Lawrence waterway and the great amount of public interest that has been manifested in it that a full and complete engineering investigation of the project, participated in by civilian engineers of both governments affected, should be made to determine the facts with respect to navigation, power, alternative routes and any other relative matters which may be involved.

Endorsing the recommendation of its Executive Board, the Council passed a resolution urging that sanitary engineers in the United States Public Health Service be made commissioned officers.

The Committee on the Storage of Coal reported informally that the complete findings of the Committee would be made public next month.

The Council voted to continue its representative, Mr. Rudolph P. Miller, Consulting Engineer of New York City, on the National Board for Jurisdictional Awards.

In his farewell address to the Council, President Cooley said that the progress of industry and social well being were so intimately bound up with engineering that the American engineer should recognize that the growth of our civilization imposes upon him other duties than those to which he has long been accustomed.

A notable event of the Washington meeting was the Annual Dinner of the American Engineering Council on the evening of January 10th at the Chevy Chase Club. President Cooley presided, and addresses were made by Secretary Hoover, President Nicholas Murray Butler of Columbia University, Assistant Secretary Dwight F. Davis of the War Department, President Hartness of the Council and the Italian Ambassador, Don Gelasio Caetani.

Secretary Hoover said: "There is somewhere to be found a plan of individualism and associational activities that will preserve the initiative, the inventiveness, the individual, the character of man and yet will enable us to synchronize socially and economically this gigantic machine that we have built out of applied sciences. Now, there is no one who could make a better contribution to this than the engineer, but to make that contribution our engineers in the future have got to have a broader and stronger place in our world affairs than they have today. We can not be turning men out of our universities as we are in many cases today purely mechanical machines devoted to some theory built on applied sciences. If the engineer is going to take his part in this community, is going to give expression to those things that he can express best, he must start with a sense of his public obligations as well as his professional knowledge."

Dr. Butler, in emphasizing the need of broader engineering education and of greater engineering participation in the social, economic and political life of the country, said: "The engineer is an administrator of necessity, and what the people of this country

and the world want, is more emphasis on administration and less on legislation, more on the engineer and less on the laws making power. . . . . We are responsible for the work of the social, political and economic systems and it is astonishing how much of this work would fall under the head of engineering, properly described and defined."

Assistant Secretary Davis described the industrial mobilization plans of the War Department. He appealed for the cooperation of the engineer.

ADMINISTRATIVE BOARD FOR 1924.

The Administrative Board for 1924 held its Organization Meeting at the close of the meeting of the American Engineering Council. Mr. L. W. Wallace was unanimously re-elected Executive Secretary. Col. John H. Finney was appointed Chairman of the Finance Committee. Messrs. Townley and Williams were elected Vice-Chairman of the Administrative Board.

Various administrative matters were acted upon, including the adoption of a budget for the year. The Administrative Board consists of twenty-five members, five of whom are representatives of the A. I. E. E. as follows: Calvert Townley, John H. Finney, Dugald C. Jackson, L. F. Morehouse and Chas. E. Skinner.

NATIONAL PUBLIC WORKS CONFERENCE

A Conference on national public works was held in Washington on January 9th and was attended by representatives of sixty-three engineering and allied organizations. The Conference adopted resolutions favoring a reorganization of Federal departments, a portion of which read as follows: "This Conference particularly indorses grouping and coordinating within an existing department, preferably renamed a Department of Public Works, the construction and administration of all non-military public works."

It was voted to set in motion again the nationwide movement for the establishment of a Department of Public Works which, it was said, would save millions annually to the government and would promote efficiency and stability in the conduct of Federal affairs. The movement will be directed by the American Engineering Council from its national headquarters in Washington. In association with the Council, there will be an advisory group composed of one representative from each participating organization.

Philip N. Moore of St. Louis, former chairman of the War Minerals Relief Commission, and one of the original sponsors of the public works project, was chairman of the Conference, which was addressed by Secretary Hoover of the Department of Commerce, who said:

"The proposal that the construction activities of the Government should be segregated in one place, under a single-headed administration, has been advocated by our engineers in this country over five years.

"The obvious economies to be had by a consolidation of our construction activities, economies in administration and in the purchase of supplies, are all to my mind purely incidental to what the engineer is endeavoring to accomplish. What we are wanting to accomplish and what is of far more importance than that is that we should have some central point for the inauguration of national policies of construction, some point where there can be a consideration given to the whole construction policies of the Government and their correlation to the private construction agencies of the country. Indeed, the Government is vastly involved in problems of navigation, waterways and port-improvement, and it is vastly involved in problems of reclamation. During the last three years there have been many problems of power, on a very large scale, that have formed a large part of this work. At the present moment works of that kind are being dealt with in anything from five to fifteen departments or agencies of the Government.

"We have had periods of time when transportation agencies have been practically at a stand still and it is no stretch of the imagination to conclude that the cost of the stagnation of transportation in 1920 alone would exceed a billion of dollars.

"There are problems that naturally come to the engineer. It must be his foresight and his vision that will find a solution, but there must be some central point in the Government where these problems may be solved and where policies looking to their solution may be inaugurated. At the present moment we are dependent on the knowledge and vision of four hundred and eighty different members of Congress, representing different sections of the country. In the adoption of legislation bearing on the improvement of harbors and navigable streams, and so forth, the net result has been that we have improved vast numbers of streams that have no great demand for traffic.

"We had thought that at the present stage of our national development, the most constructive and possible course to follow would be that if we could draw together all the construction functions of the Government into one group, even though that group was not accredited with a Cabinet position, it would have laid the foundation, would have given the start, to the attainment of the goal which is the ultimate desire of our American engineers. To increase the members of the Cabinet at the present time in order to make way for the demands of the groups of the country who support public health, public works, public education, the merchant marine, transportation, mines, and for eleven different groups, is not only hopeless from a political point of view but extremely inadvisable. Therefore, I have counselled at all times that we would make more progress if we could segregate those functions that relate to public works into a group and put that group into some department, the character or name of the Department matters very little, and build upon that foundation during the next generation."

NATIONAL RESEARCH COUNCIL

MEETING OF THE DIVISION OF ENGINEERING IN NEW YORK

About sixty leading executives of large corporations and men prominent in business life were present at a recent meeting of the Division of Engineering of the National Research Council at the University Club, New York City. The primary function of the meeting was to show industrialists the value of research and the benefits which may be derived thereform. Among the speakers were Wm. H. Bassett, Technical Superintendent and Metallurgist of the American Brass Company, Charles F. Kettering, President of the General Motors Research Corporation, A. D. Little of Arthur D. Little, Incorporated, and W. R. Whitney, Director, Research Laboratory of General Electric Company.

Addresses Wanted

A list of names of members whose mail has been returned by the Postal Authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York, N. Y.

All members are urged to notify the Institute headquarters promptly of any change in mailing or business address, thus relieving the member of needless annoyance and also assuring the prompt delivery of Institute mail, the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work.

1.—Robert J. Ardiff, 2329 N. Delaware St., Indianapolis, Ind.
2.—Paul H. Burkhart, 361 Temple St., New Haven, Conn.
3.—Mal L. Dodson, 1514 Van Buren St., Wilmington, Del.
4.—R. C. Elliott, Box 502, Wenatchee, Wash.
5.—Robert J. Latorre, 157 Henry St., Brooklyn, N. Y.
6.—Wm. I. Milburn, 915 Jackson St., Allentown, Pa.
7.—R. E. Ottman, 265 Snyder St., Orange, N. J.

Engineering Societies Library

The library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 6 p. m.

BOOK NOTICES (DECEMBER 1-31, 1924)

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statements made; these are taken from the preface or the text of the book.

All the books listed may be consulted in the Engineering Societies Library.

BILDTELEGRAPHIE.

By Arthur Korn. Berlin u. Leipzig, Walter de Gruyter & Co., 1923. 146 pp., illus., diagrs., 6 x 4 in., boards. .25.

A brief survey of the most important methods and apparatus for transmitting handwriting, drawings and photographs by telegraphy. A historical introduction reviews the early investigations, reaching back over fifty years. The principles of telegraphic copying and of writing at a distance are then explained and the methods for transmitting photographs are set forth. While the book gives special attention to Dr. Korn's own methods, those of other investigators are not neglected. The final chapter discusses television.

ELECTRIC GENERATORS, MOTORS AND CIRCUITS. LIGHTNING... CONDUCTORS, PROTECTORS AND ARRESTERS.

By Shiv Narayan. Roorkee, India, The author, 1924. (Electrical Engineering Booklet, No. 1 and No. 3). No. 1, 32 pp., illus., diagrs., 9 x 6 in., No. 3, 35 pp., illus., diagrs., 9 x 6 in. paper. $.50 each.

These pamphlets, by the Professor of Electrical Engineering and Physics at Thomason College, Roorkee, India, are intended for students and those in search of elementary information on their subjects. The first contains data on direct-current generators, motor and currents; the second describes lightning and the methods in use to protect buildings, machinery and electric lines. The books are non-mathematical and the author endeavors to present his information in an interesting way.

ELEKTRISCHE TEMPERATUR-MESSGERATE.

By Georg Keinath. Münich u. Berlin, R. Oldenbourg, 1923. 275 pp., illus., diagrs., 10 x 7 in., paper. $2.40.

This is an elaboration of the chapter on pyrometers in the author's book, the *Technik der Elektrischen Messgeraete.* It includes sections on thermoelectric pyrometers, resistance thermometers, radiation pyrometers, instruments for electric pyrometers and on the applications of electric thermometry in power plants, glass and ceramic works, the metal industry and electrical machinery. The book is written especially for the man in practise who wishes to know how such apparatus works and what its properties are.

ELEMENTS OF STORAGE BATTERIES.

By Cyril M. Jansky & Harry P. Wood. N. Y., McGraw-Hill Book Co., 1923. (Industrial education series). 241 pp., illus., diagrs., tables, 9 x 6 in., cloth. $2.50.

This book is intended to meet the need for simple, elementary exposition of the principles, operation and maintenance of storage batteries, which has been created by the extensive use of these converters of energy and by the radical changes in practise during recent years. The authors have kept in mind the needs of the man without special training who uses or operates storage batteries and wishes to know something about the operation and repair of them.

ENGINE-ROOM PRACTISE.

By John G. Liversidge. 11th edition. Lond., Charles Griffin & Co.; Phila., J. B. Lippincott Co., 1923. 429 pp., illus., diagrs., 8 x 5 in., cloth. $6.00.

This textbook is intended for students and apprentices but should also be useful to young engineers for reference. It covers the care, maintenance and repairing of the machinery of steamships, including the auxiliary electric and refrigerating machinery, and has chapters on the duties of engineers in the Royal Navy and leading steamship companies. The present edition has been enlarged by the addition of information on steam turbines and has been revised throughout.

ENGINEERING DRAWING.

By H. H. Jordan & R. P. Hoelscher. N. Y., John Wiley & Sons; Lond., Chapman & Hall, 1923. 351 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.00.

A textbook on general engineering drawing which endeavors to present the essentials of the subject in a harmonious course. The first section of the book sets forth the elementary fundamental theories of drawing, describes the four fundamental kinds of projections, and shows how they are applied in mechanical and freehand drawing. It also discusses shop terms and process, sketching and the reproduction of drawings.

In the second section these principles are applied to various fields of drafting, such as architectural, structural, map and patent office drawing. Chapters on design and on chart and diagram drawing are included. An appendix contains symbols and conventions, methods of geometrical construction and tables of data.

INTRODUCTION TO THE STUDY OF ALTERNATING CURRENTS.

By Albert E. Clayton. Lond., & N. Y., Longmans, Green & Co., 1923. 296 pp., diagrs., 9 x 6 in., cloth. $3.50.

This textbook for beginners aims to assist them to a sound knowledge of the fundamentals which are essential to advanced study and also to successful practise. The author has restricted himself to a discussion of circuits, an elementary but thorough treatment of the transformer and polyphase alternator and an elementary treatment of the polyphase induction motor. Little mathematical knowledge is necessary.

LECONS SUR LES FONCTIONS UNIFORMES.

By Gaston Julia. Paris, Gauthier-Villars et Cie., 1923. (Collection de monographies sur la théorie des fonctions). 149 pp., 9 x 6 in., paper. 15 fr.

This work, one of a series of monographs on the theory of functions, is a course of lectures given in 1920 at the College of France on the Peccot foundation. It is intended to be understandable by anyone with a knowledge of analysis.

After a preliminary chapter, the author studies Picard's theorems and the extensions of Landau, Carathéodory and Schottky; the normal families of functions; the behavior of a function around an essential singular point; the continuous and discontinuous regular approximation of an essential singular point; and the discontinuous irregular approximation of an essential regular point. The book includes the personal contributions of the author as well as a review of previous work.

MAKERS OF SCIENCE: MATHEMATICS, PHYSICS, ASTRONOMY.

By Ivor B. Hart. Lond., Oxford University Press, 1923. 320 pp., illus., por., 8 x 5 in., cloth. $2.75. (Gift of Oxford University Press. American Branch).

This book is designed to give students of science an elementary account of the history of its development. The author has adopted the biographical method and presents his material through biographies of a series of individuals, from Aristotle to Kelvin, who have had an important influence on our knowledge of the sciences under consideration. These biographies are linked together, so that a connected history of some of the broader movements in scientific history is obtained.

MANUAL DE INSTALACION DE RUEDAS PELTON.

By Gabriel Sanin Villa. Colombia, S. A., Antonio J. Cano, [1923]. 154 pp., tables, 9 x 6 in., paper. (Price not given).

A practical handbook on the selection and installation of Pelton wheels. Explains the calculations necessary, describes the accessories and contains the tables required by the engineer. The book, the work of a member of the American Institute of Mining and Metallurgical Engineers, was awarded a gold medal at the Exposicion Industrial de Medellin, 1923.

THE NEW PHYSICS.

By Arthur Haas. N. Y., E. P. Dutton & Co., [1923]. 165 pp., 8 x 5 in., cloth. $2.50.

Contents: Electromagnetic theory of light.—Molecular statistics.—Electron theory.—Quantum theory.—Theory of the chemical elements.—Theory of relativity and gravitation.—Historical summary.—Index.

In these lectures the author has supplied a connected, illuminating account of the present day structure of physics, in a form within the reach of the average scientific reader. Mathematical formulas have been omitted.

PERSONNEL MANAGEMENT.

By Walter Dill Scott and Robert C. Clothier. Chicago & N. Y., A. W. Shaw Co., 1923. 643 pp., illus., diagrs., tables, 8 x 5 in., cloth. $4.00.

The authors have attempted to outline the principles of personnel adjustment in industry as they are known today and to show how these principles may be used as a basis for creating and maintaining agencies for the adjustment of the individual to the work he is best qualified to do. Discusses such questions as the use of rating scales, tests of mental alertness and of special ability and control charts. References accompany each chapter.

PRINCIPLES AND PRACTISE OF TELEPHONY; Vol. 1, Principles and Apparatus. Vol. 2, Circuit Elements and Power Plants. Vol. 3, Toll Equipment, Traffic and Trunking.

By Jay G. Mitchell. N. Y., McGraw-Hill Book Co., 1923. 3 volts., illus., 8 x 5 in., cloth. $2.50 each.

These books form part of a five-volume text on telephone engineering, based upon material which first appeared as a serial in Telephony, entitled "Home Study Course in Telephony." The work is intended for men engaged in telephone work who wish to learn the principles that underlie the apparatus and methods which they use and to broaden their acquaintance with telephony.

SWITCHING EQUIPMENT FOR POWER CONTROL.

By Stephen Q. Hayes. N. Y., McGraw-Hill Book Co., 1921. 463 pp., illus., diagrs., 9 x 6 in., cloth. $4.00.

This, the first American book on the subject, is primarily intended to furnish the information which the actual switchboard operator needs in order to keep the equipment in his charge in good condition. The varieties of switches, fuses, circuit breakers, relays, lightning arresters and other apparatus are described first and their purposes and capabilities explained. This is followed by consideration of the main connection in a power plant and the ways to install them to secure the greatest security and flexibility. The book ends with chapters on switchboard panels, control desks and the general arrangement of the switching equipment in the plant.

TECHNICAL WRITING.

By T. A. Rickard. 2d edition. N. Y., John Wiley & Sons; Lond., Chapman & Hall, 1923. 337 pp., 8 x 5 in., cloth. $2.00.

Contents: General principles.—Naturalness.—Clearness.—Precision.—Superlatives and the superfluous.—It, one, where, while, since.—The subjunctive, shall and will, and the possessive.—Relative pronouns.—Prepositions and preposition-verbs.—Hyphens and compound words.—Slovenliness.—Jargon.—The wrong word.—Construction—Punctuation.—Composition.—Style.

Mr. Rickard's book will be useful to every engineer who desires to write clearly, correctly and pleasantly. He calls attention to many common faults in technical writing, illustrates them by many examples and shows how they might have been avoided. The advice given is practical and is based on lengthy editorial experience. The new edition has been corrected, and partly rewritten, and enlarged by two new chapters.

VERSCHLEIERUNG DER ANGABEN VON ELEKTRIZITATSZAHLERN UND ABHILFE.

By Arthur Geldermann. Berlin, Julius Springer, 1923. 126 pp., diagrs., 9 x 6 in., paper. $1.45.

A book on methods of preventing or detecting theft of electric power. The author describes various methods for influencing the registration of meters and shows how these may be detected or prevented. The discussion is confined to three-phase distribution systems. The book is intended for those engaged in setting meters and for inspectors.

Past Section and Branch Meetings

SECTION MEETINGS

Baltimore.—November 16, 1923, Engineers' Club. Subject: "Problems of Electrochemistry and Electrometallurgy." Speaker: Mr. E. W. Rouse, Jr. Attendance 60.

November 17, 1923. Inspection trip to the Baltimore Copper Works. Guides were appointed by the company to point out to the members, who had been divided into groups of ten, the interesting features.

December 14, 1923. Engineers' Club. Subject: "The Engineer." Speaker: Dr. S. W. Stratton, President of Massachusetts Institute of Technology. This meeting was held jointly with the local Branch of the A. S. M. E. and the Alumni of M. I. T. Association of Baltimore. Attendance 90.

Chicago.—November 26, 1923. Joint meeting with Western Society of Engineers. Subject: "High-Voltage Underground Cable Practise in Europe and America." Speaker: Mr. D. W. Roper. Attendance 300.

Cincinnati.—December 13, 1923. Assembly Hall, Union Gas & Electric Company. Subject: "A Year In Africa." Speaker: Mr. Thomas Duncan, President, Duncan Electric Mfg. Company, Lafayette, Indiana. Attendance 67.

Cleveland.—December 11, 1923, Hotel Winton. Subject: "Telephone Development since 1900." Speaker: Mr. Bancroft Gherardi, of the American Telephone and Telegraph Company. The talk was illustrated by many lantern slides. Attendance 275.

Connecticut.—December 11, 1923, Chamber of Commerce Hall, Waterbury, Conn. Subject: "An Informal Talk on Copper." Speaker: Mr. William H. Bassett, of the American Brass Company, Waterbury, Conn. The talk was illustrated by lantern slides. Attendance 75.

Denver.—December 14, 1923, Adams Hotel. The meeting was devoted to a symposium on Heavy Railway Electrification, illustrated by lantern slides. Mr. H. B. Barnes, Consulting Engineer of Denver, gave a pleasing and interesting address on "The Historical Development of Railway Electrification;" Mr. F. C. Hanker, of the Westinghouse Electric and Manufacturing Company of Pittsburgh, very ably presented "Recent Developments and Future Possibilities of Railway Electri-

fication;" Mr. H. D. Randall, Denver District Manager of the General Electric Company, presented a paper on "Electrification Economics" which clearly demonstrated the economic status of the railways as related to electrification. Attendance 50.

Erie.—December 19, 1923, Chamber of Commerce. Subject: "Railroads of the Japanese Empire." Speaker: Mr. S. T. Dodd, of the General Electric Company, Schenectady, N. Y. The lecture was illustrated with lantern slides and showed what great progress the Japanese are making in railroad electrification. Attendance 65.

Fort Wayne.—December 13, 1923, G. E. Club Rooms. Subject: "Engineering Education." Speaker: Professor W. A. Pfeifer, of Tri-State College. Angola, Indiana. The program closed with three reels of motion pictures from the Western Electric Company. Attendance 64.

Indianapolis-Lafayette.—December 14, 1923, Chamber of Commerce. Business meeting. Attendance 18.

Ithaca.—November 9, 1923, Franklin Hall, Cornell University. Subject: "The Relation of Research to Invention and Development." Speaker: Mr. C. E. Skinner, of the Westinghouse Electric and Manufacturing Company. Attendance 85.

Kansas City.—January 7, 1924. City Club. Joint meeting with Engineers' Club to listen to Mr. D. H. Redinger, Resident Engineer on the Big Creek Hydro-Electric Project of the California Edison Company. Two reels of pictures and slides were shown. This was educational and entertaining, showing the immensity of the hydroelectric project and the natural wonders of the mountain gorges and waterfalls. Following the presentation of the subject the Engineers' Club retired and the A. I. E. E. Section went into business session. Election of officers as follows: Chairman, Mr. R. L. Weber; Secretary-Treasurer, Mr. Gailen E. Meredith. Attendance 85.

Los Angeles.—December 19, 1923, Los Angeles City Club. The guest of honor and speaker of the evening was Professor Harris J. Ryan, President of the A. I. E. E. Professor Ryan first reviewed briefly the history of the A. I. E. E. and its growth and activities from its founding forty years ago. He then presented the paper of the evening, "Researches Relating to High-Voltage Transmission," illustrated with lantern slides. Professor R. W. Sorensen and Messrs. J. A. Lighthipe, H. A. Barre, E. R. Northmore, G. A. Damon and other members and past offices of the Section contributed to the meeting with interesting comments on the tremendous strides that have been made in the development and transmission of electrical power in the Southwest. Attendance 107.

Lynn.—December 20, 1923, G. E. Hall. Subject: "Financing Industry." Speaker: Mr. W. Irving Bullard, Vice-President of the Merchants National Bank, Boston, Mass. Attendance 110.

January 2, 1924, G. E. Hall. Subject: "Recent Development in Hydro-Electric Practise." Speaker: Professor Charles M. Allen, of Worcester Polytechnic Institute. Attendance 200.

January 5, 1924. Inspection trip to U. S. Navy Yard in Charlestown. Special transportation was provided to and from Lynn for those desiring it. Upon arriving at the Navy Yard the party divided into groups which were conducted over the grounds by guides provided by the Navy Department. The Rope Walk and Machine Shop, the Electric Department, as well as several ships, were visited. Attendance 275.

Milwaukee.—November 21, 1923, Milwaukee Athletic Club. Subject: "The Electricity Supply Industry and the Engineer." Speaker: Mr. R. F. Schuchardt. Attendance 200.

Oklahoma.—December 15, 1923, Tulsa, Oklahoma. Subject: "Insulators." Speaker: Mr. A. M. Jackson, of the Locke Insulator Company. Attendance 18.

Philadelphia.—December 10, 1923. Subject: "Supervisory Control." Speakers: Messrs. Zogbaum, Stewart and Wensley. Talk was supplemented by demonstrated apparatus. Attendance 230.

Pittsburgh.—November 15, 1923, William Penn Hotel. Subject: "Furnishing Telephone Service in a City the Size of Pittsburgh." Speaker: Mr. F. J. Chesterman, Chief Engineer, The Bell Telephone Company of Pennsylvania. The talk was supplemented by lantern slides, moving pictures, and by a very interesting demonstration of automatic machine switching apparatus. Attendance 145.

December 13, 1923, William Penn Hotel. Subject: "Air as an Insulator and Conductor." Speaker. Dr. Joseph Slepian, Research Engineer, Westinghouse Electric and Manufacturing Company. Attendance 165.

Pittsfield.—December 13, 1923, High School Auditorium. Subject: "Electrification of Steam Roads." Speaker: Mr. A. H. Armstrong, of the General Electric Company. Attendance 125.

January 3, 1924, G. E. Auditorium. Subject: "Paint." Speaker: Dr. F. P. Ingalls, Chief chemist, John W. Masury & Son, Brooklyn, N. Y. Attendance 125.

Providence.—December 18, 1823. Joint meeting with Providence Engineering Society. Subject: "Historical Developments of the Incandescent Electric Lamp." Speaker: Mr. Henry Schroeder, of the Edison Lamp Works of the General Electric Company. Attendance 60.

January 4, 1924. Joint meeting with Power Section of Providence Engineering Society. Subject: "Some Features of Modern Large Turbine Installations." Speaker: Mr. Linn Helander, of the Westinghouse Electric and Manufacturing Company. Attendance 40.

Schenectady.—January 5, 1924, Edison Club. Subject: 'Railroads of the Japanese Empire." Speaker: Mr. S. T.. 'Dodd, of the General Electric Company, Schenectady, N. Y The lecture was well illustrated with lantern slides. Attendance 180.

Springfield.—December 17, 1923. Subject: "Carrier Current Communication and Carrier Current Control." Speaker: Mr. G. Y. Allen, of the Westinghouse Electric and Manufacturing Company. Attendance 85.

Spokane.—November 9, 1923, Davenport Hotel. Subject: "Illumination and Eye Strain." Speaker: Mr. H. T. Plumb. Attendance 75.

Toronto.—December 14, 1923, Electrical Building, University of Toronto. Subject: "Insulator Depreciation." Speaker: Mr. W. T. Goddard, of the Canadian Porcelain Company, Hamilton. The talk was illustrated with lantern slides. Attendance 70.

January 4, 1924, Electrical Building. Subject: "Regulation of Frequency for Hydro-Electric Systems." Speaker: Mr. Gordon O. Philp, of the Hydro-Electric Power Commission. Attendance 80.

Urbana.—December 13, 1923, University of Illinois. Joint meeting with Physics Colloquium and Electrical Society. Subject "Models for the Investigation of Antennae and Radio Transmission." Speaker: Professor J. T. Tykociner, of the University of Illinois. Attendance 160.

Utah.—November 6, 1923. Subject: "Applying Fundamental Principles of Light to the Lighting Installation." Speakers: Mr. A. B. Oday, of the Edison Lamp Works, Harrison, N. J.; Mr. H. C. Meredith, of the Ivan-ho-Regent Metal Works, General Electric Company, Cleveland, Ohio. Attendance 50.

December 12, 1923. Subjects: "The Flynn-Weichsel Motor," by Mr. L. Brendenberger, of the Wagner Electric Corporation; "The New High Power Radio Station at Fort Douglas," by Mr. H. J. Ellingson, of the General Electric Company. The radio station at Fort Douglas was inspected and its working explained and demonstrated by Mr. D. S. Breitenbach, Radio Engineer, Signal Corps, U. S. Army. Attendance 75.

Vancouver.—December 7, 1923, Metropolitan Building. Business meeting. A report on the Pacific Coast Convention

was made by Mr. T. H. Crosby who attended as the Section's delegate. Attendance 12.

Washington, D. C.—Cosmos Club Hall. Subject: "Conditions in Europe." Speaker: Mr. William Knowles Cooper, General Secretary of the Y. M. C. A. Attendance 190.

BRANCH MEETINGS

University of Alabama.—October 16, 1923. Talks as follows: "Railway Electrification" (taken from A. I. E. E. JOURNAL), by Mr. W. F. Graham; "Telephone Transmission" (taken from A. I. E. E. JOURNAL), by Mr. C. M. Lang; "The A. I. E. E. and the Student," by Mr. C. G. Farabee. Attendance 15.

October 30, 1923. Business meeting. Attendance 14.

November 13, 1923. Talks as follows: "The Advantages of the A. I. E. E.," by Mr. M. S. Merritt; "Engineering as a Profession," by Mr. J. A. Zabel; "Direct-Currents," by Mr. C. S. Carlton. Attendance 11.

December 11, 1923. Business meeting and election of officers as follows: Chairman, C. S. Carlton; Vice-Chairman, C. M. Lang; Secretary-Treasurer, W. F. Graham; Publicity-Secretary, J. A. Zabel. Attendance 15.

University of Arkansas.—December 12, 1923. Election of officers as follows: Chairman, J. A. Cunningham; Vice-Chairman, Hugh McCain; Treasurer, Ed. Parkes; Secretary C. E. Bowman. Subjects: "Upper Falls Development of the Washington Power Company" by Mr. Joel Blake; "The Electric Furnace" by Mr. R. C. Cross; "Interconnection in New York State" by Mr. Hugh McCain. Attendance 23.

Case School of Applied Science.—November 22, 1923. Joint meeting with Cleveland Section of A. I. E. E. Subject: "Electrification of Steam Railroads" (illustrated). Speaker: Mr. A. H. Armstrong, of the General Electric Company. Attendance 35.

December 14, 1923. Professor H. B. Dates gave a short talk on the advantages of get-together meetings. Mr. J. P. Kobrack, of the Ohio Bell Telephone Company, talked on the future developments of the company and how various plans were laid out a score of years in advance. Attendance 40.

Clemson Agricultural College.—January 10, 1924. Subjects: "D. C. Power Generation for Steel Plant Loads" by Mr. S. W. Henry; "Switching Apparatus for Steel Mills" by Mr. F. L. Cary; "Adjustable Speed Main Roll Drives" by Mr. F. F. Dean. Attendance 18.

Iowa State College.—December 12, 1923. Subject: "The Evolution of Business." Speaker: Professor A. T. O'Donnell. Attendance 11.

University of Iowa.—December 10, 1923. Subjects: "The History of the Electric Lamp and a General Discussion on Modern Lights," by Mr. B. D. Panth; "Light Signal Systems for Traffic" by Mr. F. J. Spenner; "The Emmet Mercury Turbine Manufactured by General Electric Company for the Hartford Electric Light and Power Company" by Mr. H. W. Stanton. Attendance 49.

December 17, 1923. Subjects: "Illumination of Aerial Mail Fields for Night Flying—With Special Reference to Smith Field at Iowa City" by Mr. C. Von Hoene; "Twenty-Two Thousand Volt Electric Steam Boiler Used by Brown Pulp and Paper Company at Berlin, N. H." by Mr. E. L. Weber. Attendance 50.

January 7, 1924. Subject: "Electric Heat for Commercial and Domestic Use." Speaker: Mr. L. M. Bates. Attendance 50.

University of Kansas.—December 6, 1923. Subject: "The Business Training of the Engineer." Speaker: Mr. G. C. Gillispie, of Kansas City, District Sales Manager, Westinghouse Company. Attendance 39.

Lehigh University.—December 14, 1923. Subjects: "The Development of High Power Vacuum Tubes" by Mr. W. E. Thompson (student); "The Development of Radio and the Limitations of Broadcasting" by Col. W. H. Slaughter, of the Western Electric Company. Colonel Slaughter brought along a set to demonstrate some of the new features in radio. Attendance 111.

University of Maine.—December 12, 1923. Subjects: "The Man Behind the Coal Pile," by Professor A. S. Hill; "Operating Power Stations," by Mr. K. L. Cyphus. Attendance 12.

Marquette University.—December 13, 1923. Subject: "Electrification of the Western Division of the C. M. & St. P. Ry. Co." Speaker: Mr. J. A. Anderson, of the C. M. & St. P. Ry. Slides were exhibited showing the various types of transportation, including the earliest and the most modern. Two reels of motion pictures gave the audience some good views of traveling through the western part of the country. Attendance 205.

Michigan Agricultural College.—December 4, 1923. Joint meeting with American Association of Engineers. A two reel film showing the manufacture of telephones and telephone cable was shown by Superintendent Marsh of the Michigan State Telephone Company. Mr. Marsh then gave a short talk on some of the problems encountered in present day telephone work. Attendance 100.

University of Michigan.—December 10, 1923. Smoker. Mr. A. Dow, President of the Detroit Edison Company, gave a very interesting talk on the company's new Trenten Channel project and gave some interesting information concerning location of power plants. their transmission problems, etc. Refreshments were served. Attendance 83.

School of Engineering of Milwaukee.—December 14, 1923. Subject: "Application of Electricity to Modern Industrial Heating" (illustrated). Speaker: Mr. D. W. Miller, Consulting Engineer on Industrial Heating of the T. M. E. R. and L. Co. Attendance 32.

University of Minnesota.—December 12, 1923. A film entitled "The Story of an Electric Meter" (furnished by the Sangamo Electric Company) was shown. Professor R. E. Kirk spoke on "Electrical Engineering in Electrochemical Industry;" and Mr. R. E. Mathes (student) on "Radio at the University of Minnesota." Attendance 58.

University of Nebraska.—January 3, 1924. Subject: "Modern Tendency in Protective Relay Practise." Speaker: Professor Edison. Attendance 24.

University of Nevada.—December 19. 1923. Mr. W. D. Scott, of the Bell Telephone Company of Sacramento, gave an interesting lecture on telephone engineering. The lecture wae followed with motion pictures concerning the development of ths telephone in France and Belgium. Attendance 53.

University of North Carolina.—December 13, 1923. Subject: "Some Electrical Methods of Chemical Analysis." Speaker: Professor I. M. Bell. Attendance 34.

Northeastern University.—December 19, 1923. Professor R. Porter presented a paper entitled "Possibilities of Radio Research in this Branch;" and Professor William L. Smith gave an illustrated lecture on testing work at Underwriters' Laboratories in New York and Chicago. Attendance 33.

Notre Dame University.—December 17, 1923. Mr. Frank Egan gave a short resumé of the scope of the radio field and of the opportunities it offers. The guests of the evening were Mr. Frank Freimann and Mr. Earl Ensign, of the Lyradion Manufacturing Company, who demonstrated and explained a six-tube radio receiving set. Attendance 70.

January 7, 1924. Subjects: "Electric Railways and Block Signals" by Mr. Edward S. Sullivan; and "Condensers" by Mr. James Smith. Attendance 30.

Ohio Northern University.—December 20, 1923. Subjects: "Pioneers of Electricity" by Mr. Ring; "The Future of Electricity" by Mr. Funk; and a general discussion of the program for the annual engineers week, by Dean Alden. Attendance 21.

University of Pittsburgh.—October 26, 1923. Mr. G. H. Campbell spoke on Current Events, and Mr. W. T. Pyle on "Electric Furnaces." Attendance 30.

November 9, 1923. Subject: "Patents." Speaker: Mr. C. M. Ralph. Attendance 28.

November 23, 1923. Mr. F. Wills spoke on Current Events, and Mr. R. A. Fuhrer on "Electric Locomotives." Attendance 33.

Purdue University.—December 6, 1923. Joint with A. S. M. E. Subject: "Einstein's Theory of Relativity." Speaker: Professor V. Karapetoff. Attendance 650.

December 11, 1923. Joint with A. S. M. E. Subject: "Automobile Development." Speaker: Mr. N. E. Wahlberg, of the Nash Motor Company. Attendance 250.

Rensselaer Polytechnic Institute.—December 11, 1923. Subject: "The Mercury Turbine Equipment Recently Installed in the Dutch Point Station of the Hartford Electric Light Company." Speaker: Mr. C. W. Mayott, of the Hartford Electric Light Company. Attendance 214.

Rutgers College.—December 20, 1923. Subjects: "Preservation of Wood" by Mr. W. H. Dunn '25; and "Discussion of Induction Motors" by Mr. E. J. Butler '24. Attendance 15.

University of Southern California.—December 13, 1923. Business meeting. Attendance 48.

December 19, 1923. The Branch was addressed by Professor H. J. Ryan, President of A. I. E. E. Attendance 152.

Stanford University.—December 11, 1923. Subject: "Some of the Problems Encountered by the Telephone Engineer," (illustrated). Speakers: Messrs. C. D. Howe and Everett M. Calderwood, of the Pacific Telephone and Telegraph Company. Attendance 50.

Syracuse University.—November 6, 1923. Subjects: "Energy Resources" by Mr. P. P. Chalupa; and "The Repair of Street Railway Motors" by Mr. F. W. Mahley; also an impromptu talk by Professor G. S. Parker was given on "Some of the Problems of the Commonwealth Edison Company." Attendance 21.

November 13, 1923. Subjects: "Highway Engineering" by Mr. E. J. Thomas; and "The Development of Vacuum Tubes" by Mr. H. H. Graley. Attendance 21.

November 20, 1923. Subjects: "The Electrification of Railways" by Mr. H. M. Field; and "Single-Phase Rectifiers" by Mr. L. F. Biosca. Attendance 19.

November 27, 1923. Subject: "Parallel Operation of Alternators." Speaker: Mr. R. A. Prosser. Attendance 20.

December 6, 1923. Subject: "The Development of A. C. Generators." Speaker: Mr. R. S. Langworthy. Attendance 20.

December 17, 1923. Subject: "The History and Development of the A. I. E. E.." Speaker: Dean Paul M. Lincoln, of Cornell University. Attendance 40.

December 19, 1923. Subject: "Electrical Refrigeration." Speaker: Professor G. S. Parker. Attendance 20.

January 4, 1924. Subject: "Radio Transmission." Speaker: Mr. Carl Woese. Attendance 20.

University of Tennessee.—December 19, 1923. Subject: "Engineering Notes on Europe" (illustrated). Speaker: Dr. C. A. Perkins. Attendance 55.

University of Texas.—November 8, 1923. Election of officers as follows: Chairman, Mr. J. P. Woods; Secretary, Mr. W. K. Sonnemann. Subject of talk: "Railroad Electrification." Speaker: Mr. J. M. Bryant. Attendance 14.

December 10, 1923. Subject: "Hydro-Electric Development at Priests Rapids." Speaker: Mr. G. C. Hengy (student). Attendance 12.

West Virginia University.—December 3, 1923. The following papers were given: "Need of Engineers in Industry To-Day" by Mr. Holmes; "Notes on Super-Power Plants" by Mr. Gramm; "Starting of Polyphase Induction Motors" by Mr. Callaham; "Under-Graduates Course in Telephony" by Mr. Hall; "Protecting Buildings Against Lightning" by Mr. Copley; "Operation of Rotary Converters" by Mr. Tennant; "Variable Speed A. C. Motors" by Mr. Steele; "Successful Operation of Turbo-Generator as a Synchronous Motor" by Mr. Hill; "Relation of Illumination to Production" by Mr. Naylor; "Moving Platform Systems" by Mr. Henderson; "Super-Power" by Mr. Pugh. Attendance 34.

University of Wisconsin.—January 9, 1924. Subject: "Opportunities for Employment in Public Utilities." Speaker: Mr. G. C. Neff, of the Wisconsin Light and Power Company. Attendance 21.

PERSONAL MENTION

A. G. MERRIMAN has severed his connection with Purdue University and is engaged in private research work in Memphis, Tenn.

JOHN J. KOETZLE has accepted a position with the Philadelphia Electric Company, having recently left the employ of the Westinghouse Electric & Mfg. Co.

GEORGE A. LAJOIE has resigned his position with the Southern Canada Power Co., Montreal, Que., and is now with the Electrical Commission of the City of Montreal.

R. E. DONAHOE has severed his connection with the Westinghouse Electric & Mfg. Co., to enter the employ of the Phoenix Utility Company, at Duluth, Minn.

T. Y. WOO, who has been connected with the Nanyang College at Shanghai, China, is now in the Locomotive Dept. of the Kiaochow Tsinan Railway, Tsingtau.

HOWARD E. BATSFORD became associated with the Adirondack Power and Light Corp., in the Construction Department, in charge of construction at the Inghams Falls, N. Y.

L. C. ABEL is at present Construction Superintendent for the Merkle Machinery & Contracting Co., Kansas City, Mo., and is engaged in building a power plant at Kewanee, Ill.

A. R. SCHILLER has become associated with the Manchester Traction Light & Power Co., Manchester, N. H. He was previously with John A. Stevens of Lowell, Mass.

ARTURO GONZALES, JR., has recently become Treasurer of the Antillas Electrical Corp., San Juan, P. R. He was formerly with the Porto Rico Railway, Light & Power Co. at San Juan.

W. H. Patterson who has until recently been associated with the Kaestner & Hecht Elevator Company, has become Vice-President of The John H. Dunham Company, Chicago, Ill.

EDWIN H. SEAMAN, formerly Director of the Advisory and Engineering Dept. of the Alfred M. Best Co. Inc. is now associated with Lethbridge & Co. Inc. New York N. Y. as vice-president.

A. H. MACADAM formerly Superintendent of Construction for E. L. Philips & Co. is now connected with the New York office of the Electrical Engineers Equipment Co., as Sales Engineer.

RICHARD A. DITTMAR, JR. has resigned from the Atlas Portland Cement Co., at Hannibal, Mo. and is now with the New York & New England Cement and Lime Co. at Hudson, N. Y.

R. H. BARCLEY has become associated with Stone & Webster, Inc., Boston, as an electrical engineer in the Division of Construction and Engineering. He was formerly with Starrett & Vano Vleck in New York City.

THOMAS O. KOOPMAN has severed his connection as Superintendent of Maintenance and Power of a submarine boat, and has entered the employ of the American Smelting and Refining Co., as Superintendent of the Maintenance Dept., at Maurer, N. J.

FRANK SHORT, formerly Ordnance Engineer, U. S. Army, at Aberdeen Proving Ground, Aberdeen, Md., has resigned his commission and has become Vice-President and General Manager of the Alladin Engineering Company, Inc., 149 Church St., New York, N. Y. This company succeeds the V. M. Bugg Engineering Service Co.

Obituary

John Mustard, died on December 12, 1923. He was born May 9, 1867 at Smyrna, Delaware. Upon his admission to the Institute in 1904 he held the position of Manager of the St. Louis office of the Wagner Electric Company, and he continued his connection with that company until the time of his death, when he was Eastern Sales Manager, located in Philadelphia, Pa.

Otto C. Beck, an Associate of the Institute, died on January 1, 1924. He was born and educated in Baltimore where he received training as an electrician. He was connected at various times with the Cleveland Construction Co. the Pennsylvania Water Power Co., the Ordnance School of Application, at Aberdeen, Md., the Edgewood Arsenal, and the General Electric Company in Baltimore.

William E. Holcombe, an Associate of the Institute died on December 20, 1923, at his home in Schenectady, N. Y. He was for twenty-eight years connected with the General Electric Co. in the capacity of designing engineer. Graduating from Lehigh University in 1894, he entered the Drafting Department of the General Electric Co., where he was intimately associated with the early development of the alternating-current generating apparatus. In 1908 he was put in charge of a section devoted to the design of allternators, which position he held until the time of his death.

William Hoopes, residing at the D'Arlington Apartments, Bayard Street, Pittsburgh, Pa., died at 10.00 o'clock Wednesday evening, January 9, 1924. Mr. Hoopes was born in West Chester, Pennsylvania, July 20, 1867. He was educated in the schools of West Chester and Philadelphia and in electrical engineering at Lehigh University. Upon leaving the University he was engaged for about ten years in the construction and operation of electric lighting plants and electric railways. He then came to Pittsburgh and joined the staff of the Westinghouse Electric & Manufacturing Company. In 1900 he became the chief electrical engineer of the Aluminum Company of America and since then has had complete charge of all the electrical development of that organization. For the past seven years, Mr. Hoopes has also been head of the Research and Technical Departments of the same company. The rapid development and introduction of aluminum for electrical purposes and particularly for high-voltage transmission has been due to the exceptionally able and persistent work of Mr. Hoopes. His remarkable genius originated and put into successful operation many chemical and metallurgical processes which made him a recognized authority throughout the world in aluminum metallurgy.

At the time of his death he was a member of the American Institute of Electrical Engineers, the Engineers Society of Western Pennsylvania, the Pittsburgh Athletic Association and the Oakmont Country Club.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers as a cooperative bureau available only to their membership, and maintained by contributions from the societies and their individual members who are directly benefited.

*MEN AVAILABLE.—Brief announcements will be published without charge and will not be repeated, except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to **EMPLOYMENT SERVICE, 33 West 39th Street, New York City,** and should be received prior to the 15th of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription rate of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by nominal contributions made within thirty days after placement, on the basis of $10 for all positions paying a salary of $2000 or less per annum; $10 plus one per cent of all amounts in excess of $2000 per annum; temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above, will, it is hoped, be sufficient, not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case and with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

(For other employment announcement see page 52 of the Advertising section.)

POSITION OPEN

TECHNICAL GRADUATE, preferably electrical engineer or electro-chemical engineer with reading knowledge of French and German for technical library work in a large research organization. Previous library experience preferred, but not essential. Good personality necessary. Application by letter, stating education, previous experience, and salary expected. Location, East. R-3000.

MEN AVAILABLE

UNIVERSITY GRADUATE in electrical engineering, age 25, two years' experience in manufacturing concern and now in charge of the operation and maintenance of large battery installation in territory. Would like to be connected with a manufacturing or consulting firm doing work in electric railway or power transmission and offering opportunity for advancement. Eastern States preferred. B-7095.

ELECTRICAL ENGINEER, 28 years, single. Experienced in power construction as superintendent or foreman. Also mechanical experience in steam power plants with stokers and pulverized fuel. Capable of taking charge of engineering, design and drafting. Available in one week. B-7102.

COLUMBIA ELECTRICAL ENGINEER, 29 years old; experienced in rate setting, planning, production and estimating in electrical manufacturing firm; desires position in greater New York. B-7139.

RADIO ENGINEER, college education and ten years' practical experience in the radio field, four years of which have been devoted to experimental work. Can furnish satisfactory references as to character and ability. Also two years' experience in sales organization and management. Permanent position desired with well established organization in research and development work pertaining to some phase of radio communication. Permanency and opportunities for advancement more important than salary. Available at once. B-7174.

TEACHER 36; married; M. E. and E. E. Cornell; Assoc. A. I. E. E., 5 years' manufacturing and 7 years' teaching experience. Available September for associate or assistant. Professorship in Eastern or Middle-West university. B-7181.

ELECTRICAL DESIGNING ENGINEER, Technical graduate; age 40; married; 14 years' experience as designer, squad chief, chief draftsman and engineer in power plants, substations, switchboards and industrial work. Has worked with large manufacturing concerns, consulting engineers and public utility companies. At present employed, but available within reasonable time. Can furnish best of references. Location, New York City. B-7183.

ADVERTISER. Just returned after more than four years importing power plants

into China, desires position executive capacity, technical or commercial experience of 20 years embraces successively drafting, engineering and commercial in electrical and mechanical subjects including hydroelectric. Last 12 years as acting manager branch office relinquished on account of personal reasons. Age 38; married, prefer Pacific coast. Available about April 1st. B-7203.

REGISTERED ENGINEER CIVIL AND ELECTRICAL. Mem. A. I. E. E.; age 33; with twelve years' experience in the design and construction, dams power plants, transmission lines and distribution systems, surveying, map-making and sewerage systems; seeks connection as associate with firm of consulting engineers. Past two years spent in private practise. B-1173.

POSITION WANTED by technical graduate electrical engineer with experience as Westinghouse test floor apprentice, Allis-Chalmers steam turbine floor erector, central station manager, high line superintendent, hydroelectric and motor application and maintenance engineer. Holds chief engineers' license. B-7202.

ELECTRICAL-MECHANICAL ENGINEER Graduate of Turin's Polytechique (Italy) age 28; single, initiative and inventive ability, with four patents in electrical apparatus; at present draftsman; desires position with reliable concern. Knowledge of French, Italian and a little English. Willing to start from manual work, if necessary. Location, New York City preferred. B-7208.

WANTED BY UNIVERSITY TECHNICAL GRADUATE 1923; 23 years of age—a position in New York City with a future. Anxious to work for results. Experience since graduation consists of 3 months in electrical railroad shop and 3 months testing meters and trouble work for public utility. B-7204.

PROFESSOR, ELECTRICAL ENGINEER desires responsible position with a progressive and growing educational institution. Teaching experience covers basic courses from elementary to advanced also many specialized courses. Broad experience in the industry including design, application and construction work. Executive ability. Salary about $2500. Available for the fall semester. B-7083.

ELECTRICAL ENGINEER, age 39, years of experience in generating stations (hydroelectric) construction as lighting engineer, as sales engineer, as power and merchandise sales manager, in consulting and in promotion by projects, seeks permanent connection with good remuneration and therefore responsible connection with A-1 firm, New York or anywhere. B-6668.

INSTRUCTOR OF ELECTRICAL ENGINEERING, during the past four years in high grade middle west engineering college. One year of research work. B. S. in E. E. 1917 and M. S. in E. E. 1920. Associate A. I. E. E. Age 30, married. Due to lack of changes in department, no immediate chance for advancement here. Willing to go elsewhere as associate or assistant professor. B-7223.

GRADUATE ELECTRICAL ENGINEER, age 29; married, 4 years' development and test experience; 3 years' teaching; now head of a degree-granting department. Capable of taking responsibility for development of electrical and mechanical apparatus where principles of physics must be applied. Desires development work or teaching. Location, Ohio. B-7237.

GRADUATE ELECTRICAL ENGINEER with commercial education wants a good commercial position with a concern that wants a man of decision and action. Two years' shop experience with control manufacturer; one year engineering sales department. B-7239.

ELECTRICIAN-DRAFTSMAN, age 31, married. Eleven years' installation, maintenance and repair of electrical machinery, two years' mechanical, structural and electrial drafting with large crane manufacturer. Self-educated, now teaching, wants position in the Allentown-Easton section of Penna. Assoc. A. I. E. E. B-7240.

ELECTRICAL ENGINEER desires executive position as engineer or chief draftsman of manufacturing plant making small electrical or mechanical devices. 16 years' experience, 8 of which were in an executive capacity. Can put your plant on an efficient basis with just enough system no more. Age 38; Member A. I. E. E.; married, salary depending on position, but not less than $3600. B-5331.

LABORATORY ENGINEER, to take charge of electrical laboratory or department of same. Experienced in all classes of electrical testing connected with power development and distribution. Specialist in instruments, meters and precise methods of measurement. Member A. I. E. E. B-7245.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, Assoc. A.I.E.E., Mem. S. A. E., age 31, single. Unusually broad experience in design and production of control apparatus, industrial haulage equipment, storage battery locomotives, trucks, tractors and trailers. Holding responsible position with charge of design for the last 5 years with two of the largest manufacturers' companies for industrial haulage equipment. Desires position of greater responsibility with reliable organization. Location immaterial. B-7250.

CHIEF ELECTRICIAN, experienced in interior wiring, installation and maintenance of small d-c. units, construction work in factories. First class technical knowledge of both a-c. and d-c. systems. Recent graduate, radio electrician. Desires position with contractor as foreman or with manufacturing concern as chief electrician. At present employed, but can leave with a fair notice. Location immaterial. Age 25; reliable, industrious. B-7238.

CERTIFIED TECHNICAL PATENT EXPERT. Member of the Bar, Mem. A. I. E. E., and Soc. Am. Military Engr's, graduate in electrical engineering and law. 25 years' experience and engineer, patent solicitor, attorney at law and technical expert. B-7252.

HYDROELECTRIC ENGINEER, 12 years' experience in civil, mechanical and electrical fields. Have constructed, operated and managed public utilities and contracts for power disposal. American, technically trained; 36; Mem. A. S. M. E., Assoc. A. I. E. E. Several years consulting and executive engineer. Eastern section preferred. A-2280.

ELECTRICAL AND MECHANICAL ENGINEER, college graduate, age 33, with extensive experience in design and construction of power stations, industrial plants and railroad electrification, also valuation, desires connection with consulting engineers or industrial concern. Available immediately. B-6852.

YOUNG MAN, age 24; technical college graduate 1923 in E. E. Practical experience covers 4 years, training in shop system and manufacturing methods, drafting room, layout and design of electrical instruments, specifications, sales order designs. Desires a start in any branch of E. E. Willing worker. New York metropolitan locality preferable. B-6965.

TECHNICAL GRADUATE of electrical engineering course with knowledge of accounting. Age 28. Three years' diverse technical experience; desires position that leads to advancement. B-4344.

ENGINEER wants evening or part time position, experimental, development work or teaching. Technical graduate, ten years' varied experience. Location, New York City. B-6981.

ELECTRICAL ENGINEER, Assoc. A. I. E. E. 6 years' experience in design and layouts of power and substations. Maintenance and rebuilding of various marine equipment in the United States and abroad. Present employed. Southern location preferred. B-6600.

YOUNG MAN age 24; will graduate in June from an evening course in electrical engineering. Wishes to locate with an electrical concern in New York City. Has had some drafting experience. Available on one week's notice. B-7270.

ELECTRICAL ENGINEER. Graduate M. I. T., B. S. and M. S. Two years with General Electric Company. Specialized in illuminating engineering; desires connection where training, enthusiasm and aggressiveness may be capitalized. B-7271.

ELECTRICAL ENGINEER, age 40, married; technical graduate, experienced in the design of power plants, substations and distribution systems, motor application and control. Accustomed to writing specifications and supervising the preparation of drawings. Desires position with a future. B-7269.

ENGINEER AND PUBLIC UTILITY MANAGER, 17 years' experience in operation and construction in all branches of the service, including ice and refrigerating plants. Have been employed by a large company in general office as engineer in responsible charge of construction and operation, also district manager. Have obtained excellent results with coal, oil and gas as fuel. Available immediately. A-5399.

ELECTRICAL ENGINEER age 35; single; desires permanent connection with concern having opening for technical graduate with following qualifications. Ten years' experience in steam-electric plant design, construction and operation, including substations, transmission and distribution systems, street railways, reports on power prospects and appraisals. Can go anywhere but willing to make concessions for location in Ohio. B-7251.

ENGINEERING EXECUTIVE, technical graduate, 11 years' experience, valuation, production, cost, and job analysis, time study and control, engineering construction, and design. At present employed. Age 30; married; wishes to affiliate with growing manufacturing organization or industrial engineer. B-4456.

ELECTRICAL ENGINEER, technical graduate E. E. Mem. A. I. E. E., N. E. L. A. A. E. R. A. Age 44; married. Twenty years' electrical lighting and railways of same management of properties and in home office. Design and operation of transmission and distribution, municipal lighting, meter and regulator practise, power factor connection, power contracts, railway distribution, automatic signals, electrolysis and welding, track bonding. Available two weeks' notice or less. B-7220.

ELECTRICAL ENGINEER, designer of electrical construction in power systems, central and substations, electric railways, power distributions, specialist in switching, switchboards, instruments. Seventeen years' experience; age 37; married. Position wanted, project manager, engineer in charge of design, engineer in power company. Desirous of making permanent connection. Salary commensurate with responsibility. B-7290.

GRADUATE ENGINEER B. S. in E. E., 1923, age 23 years, single. Two years' experience in public utility in meter testing, line construction, and statistical work. Desire a position with an electric railway, manufacturing concern or public utility where advancement and experience are available. B-7296.

ELECTRICAL ENGINEER, technical graduate 1921, with safety work and electrical design experience, desires to break into sales promotion or construction work. Employed at present, but available on short notice. B-7190.

ELECTRICAL ENGINEER OR SECRETARY to works manager. Age 26; married; engineering college graduate. Business administration training. Six years' experience with metropolitan railway public utilities and large manufacturing companies. Desires position as secretary to executive or technical sales. Salary $2600. B-7315.

TECHNICAL GRADUATE B. S., in electrical engineering 1921; one and a half years' experience in hydroelectric plant operation, one years' substation operation, desires place on construction work. West preferred. B-7303.

MEMBERSHIP — Applications, Elections, Transfers, Etc.

ASSOCIATES ELECTED JANUARY 18, 1924

ABELL, ROSS ADAMS, Schedule Engineer, Telephone Exchange Installations, Western Electric Co., Inc., 268 W. 36th St., New York, N. Y.

ABBOTT, WINFIELD F., Electrical Tester, General Electric Co., West Lynn; res., Lynn, Mass.

*ADAMS, ROBERT MORTON, Patent Lawyer, Pennie, Davis, Marvin & Edmonds, 165 Broadway, New York, N. Y.

*AGINS, GEORGE, Technical Assistant, Electrical Testing Laboratories, 80th St. & East End Ave., New York, N. Y.

*ANDERS, RUSSELL HONER, Foreman, Meter Testing Dept., Indiana & Michigan Electric Co., 120 W. Colfax Ave., South Bend, Ind.

ASHLEY, HAMMOND, Student of Electrical Engineering, Stanford University, 611 Waverley St., Palo Alto, Calif.

ASPIN, NORMAN, Control Operator, Price Bros. & Co., Ltd., Kenogami, P. Q., Can.

AUSTIN, FRANK DOUGLAS, Surveyor & Draftsman on Maintenance, Durant Motors of Canada, Ltd., Leaside; res., Toronto, Ont., Can.

BACON, THEODORE S., Commercial Engineer, General Electric Co., 120 Broadway, New York, N. Y.

*BAILEY, JULIAN CLARKE, General Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

*BAILEY, STANTON S., Distribution Div., Engg. Dept., Commonwealth Edison Co., Edison Bldg., Chicago, Ill.

*BAKER, RALPH HENRY, Sales Assistant, Westinghouse Elec. & Mfg. Co., University Bldg., Syracuse; res., E. Syracuse, N. Y.

BALCKE, WALTER HENRY, Station Betterment Engineer, Stone & Webster, Inc., 147 Milk St., Boston, Mass.

*BALDWIN, JOHN FRANK, Student Engineer, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.

BARTHOLOMEW, GEORGE WADE, Industrial Electric Service of Erie, Erie, Pa.

BECHOFF, FERDINAND N., Chief Draughtsman, Radio Corp. of America, 66 Broad St., New York, N. Y.

BEEBE, HARRY M., Power Director, The Eastern Connecticut Power Co., Uncasville; res., New London, Conn.

BEERS, RALPH SILAS, Railway Equipment Engineer, General Electric Co., Schenectady, N. Y.

BENSON, UNO JOSEPH, Electrician, McCall Publishing Co., 236 W. 37th St., New York, N. Y.

BERGVALL, R. C., General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

*BIAVATI, JOSEPH D., Electrical Engineer, Cutler-Hammer Mfg. Co., New York, N. Y.

BLACK, HAROLD B., Instructor, Electrical Dept., Harrisburg Mechanical School, 2217 Derry St., Harrisburg, Pa.

BLAIR, JOHN STEVENSON, Senior Power Man, Bell Telephone Co. of Penn., 1631 Arch St., Philadelphia; res., Norristown, Pa.

*BLENDEN, WILFRED LEROY, Record Dept., Southwestern Bell Telephone Co., 414 Locust St., St. Louis, Mo.

*BOEHM, ALBERT, Illuminating Engineer, Westinghouse Lamp Co., 165 Broadway, New York, N. Y.; res., Irvington, N. J.

BONELL, RALPH KNUDSEN, Telephone Engineer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.

BOTTGER, RICHARD EDWARD, 3208A North 19th St., St. Louis, Mo.

BOURGEOIS, CLARENCE HENRY, Foreman, Elec. Dept., Haughton Elevator Co., Spencer St., Toledo, Ohio.

BRIES, MATT MICHAEL, Electrician, D. P. Robinson & Co., 1300 Penn Ave., Pittsburgh, Pa.

BROOKS, LAWRENCE RUSSEL, Electrical Maintenance, General Electric Co., East Lake Road, Erie, Pa.

BROWN, RALPH DeFOREST, Draftsman, Electrical Engg. Office, Pennsylvania Railroad, Altoona, Pa.

*BRYAN, HAROLD WESTWOOD, Engg. Apprentice, Union Switch & Signal Co., Swissvale; for mail, New Castle, Pa.

BUGG, VERNON M., Engineer, Planning Div., Western Electric Co., Inc., 268 W. 36th St., New York, N.Y.; res., Rahway, N. J.

*BURCHETT, ALBERT CLEVELAND, JR., Technical Apprentice, Aluminum Ore Co. of America, East St. Louis, Ill.

BUTLER, CARLTON EDWARD, Elec. Div., Service Dept., Westinghouse Elec. & Mfg. Co., 2201 W. Pershing Road, Chicago, Ill.

BUSEY, PAUL G., Vice-President, Busey's State Bank, Urbana, Ill.

CADDY, HENRY P., President, Karl Andren Co., 148 Pearl St., Boston, Mass.

CHESTER, FRED HORACE EDWIN, Electrical Engineer, Canterbury Frozen Meat Co., Belfast, N. Z.

CHRISTIE, JONATHAN S., Electrical Testing Laboratory, 616 St. Clair Ave., N. E. Cleveland, Ohio.

*CLARK, FRED K., Electrical Elevator Mechanic., Cunard Bldg., 25 Broadway, New York, N. Y.; res., Jersey City, N. J.

*CLARK, LEWIS FROTHINGHAM, Instructor, Elec. Measurements Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

CLASON, RICHARD, Electrical Draftsman, Stevens & Wood, Inc., 120 Broadway, New York; res., Brooklyn, N. Y.

COTTON, WILLIAM A., JR., Salesman of Electrical Equipment, C. E. Wise, General Motors Bldg., Detroit, Mich.

*CRILEY, WALTER, Instructor, Moore School of Elec. Engg., University of Pennsylvania, Philadelphia; res., Lansdowne, Pa.

*DAMBLY, HAROLD ALTHOUSE, Technical Asst., Philadelphia Electric Co., 2301 Market St., Philadelphia, Pa.

DAVIDSON, MAXWELL S., Chief Engineer, Western Steel Products Co., 1401 Osage St., Denver, Colo.

DANZIGER, HAROLD I., Treasurer, Danziger-Jones, Inc., 143 Prince St., New York, N. Y.

DARCHE, ALBERT THEADORE, Engineer, Goodman Mfg. Co., 48th Place & Halsted St., Chicago, Ill.

DENGLER, ARTHUR GEORGE, Electrical Engineer, New York Telephone Co., 81 Willoughby St., Brooklyn; res., Ozone Park, N. Y.

DOE, ALBION NOYES, Asst. Professor, Rhode Island State College, Kingston, R. I.

DUNN, MARTIN LUTHER, Resident Engineer, L. T. Klauder, 1065 W. 4th St., Williamsport, Pa.

*EARLE, RICHARD T., General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

*EKEROTH, WALTER MAURITZ, Inspector, Brooklyn Edison Co., Inc., 360 Pearl St., Brooklyn, N. Y.

*ELLESTAD, IRWIN MARTIN, Interference Engineer, Northwestern Bell Telephone Co., 3rd Ave., & 5th St., Minneapolis, Minn.

EMERICH, LeROY EDWARD, Salesman, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

EWING, FRANCIS ROBERT, Manufacturers' Salesman, American Laundry Machinery Co., 1328 Broadway, New York; res., Monfey, N. Y.

FAULKS, JOHN RUSKIN BROOKS, Apprentice, Electric Supply Dept., Newcastle City Council, Watt St., Newcastle, N. S. W., Australia.

*FAUS, HAROLD THEODORE, Engineering Asst., Standardizing Laboratory, General Electric Co., West Lynn; res., Lynn, Mass.

FERGUSON, CHARLES VAUGHAN, Research Engineer, General Electric Co., Schenectady, N. Y.

FERRARI, CAROLUS, Consulting Engineer, 73 W. 83rd St., New York, N. Y.

FILE, ERNEST D., Chief Electrician, R. F. & P. Railroad Co., Potomac Yard, Potomac; for mail, Alexandria, Va.

*FLOYD, DEWEY AUGUSTUS, Dist. Substation Operator, Public Service Electric Co., 225 N. Warren St., Trenton, N. J.

FROLICH, FREDRIK, Sanderson & Porter, 52 William St., New York, N. Y.

*GALBRAITH, REGINALD A. H., Lieut., Royal Canadian Corps of Signals, National Defence Headquarters, Ottawa; res., Toronto, Ont., Can.

GALLAGHER, JOHN ETHRIDGE, Engineer, Electrical Construction, Brooklyn Edison Co., 360 Pearl St., Brooklyn, N. Y.

GAULT, JAMES SHERMAN, Instructor, Dept. of Elec. Engg., University of Michigan, Ann Arbor, Mich.

GLASS, HARRY J., Manager, Electrical Dept., Fairbanks, Morse & Co., 610 Magazine St., New Orleans, La.

*GLUCK, JOHN, 1709 Park Ave., New York, N. Y.

*GOODISON, ALFRED MAXWELL, JR., Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.

*GORHAM, ROBERT CHARLES, Instructor, Elec. Engg. Dept., Cornell University, Franklin Hall, Ithaca, N. Y.

*GRANGER, HARRY INWOOD, Jackson & Moreland, 387 Washington St., Boston; res., S. Weymouth, Mass.

GRAHAM, CLINTON KENDALL, Illuminating Engineer, Springfield Light, Heat & Power Co., Springfield, Ohio.

GREENE, WILLIAM THOMPSON, Supt. Electric Meter Dept., Northern New York Utilities, Inc., Watertown, N. Y.

GREENLEAF, WALTER E., Chief Stock Keeper, West Lynn Works, General Electric Co., West Lynn, Mass.

GRIFFIN, GEORGE TAYLOR, Electrician, Bethlehem Steel Co., Sparrows Point, Md.

GRONQUIST, JOHN R., Asst. Electrical Engineer, West Penn Power Co., 14 Wood St., Pittsburgh, Pa.

GRUBER, GEORGE, Leader, Wm. Cramp & Sons, S. & E. B. Co., Norris & Richmond Sts., Philadelphia, Pa.

*GUILLEMIN, ERNST ADOLPH, Asst. Electrical Engineering Dept., Massachusetts Institute of Technology, Cambridge, Mass.
GUSTASON, CLARENCE FERDINAND, Chief Load Dispatcher, Central Indiana Power Co., 501 Guaranty Bldg., Indianapolis, Ind.
GUTH, STEFAN, 164 Sherman Ave., New York, N. Y.
HALL, CLIFTON ALFRED, Testing Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
*HAMILTON, FRANCIS ALEXANDER, JR., Sales Engineer, Central Station Dept., General Electric Co., Schenectady, N. Y.
*HARL, GUY P., Senior Student, University of Missouri, 107 S. 6th St., Columbia; for mail, Moberly, Mo.
*HAVLICK, JOSEPH, Engineer, The Milwaukee Electric Railway & Light Co., Public Service Bldg., Milwaukee, Wis.
HECK, J. HOLLAND, Instructor, Elec. Engg. Dept., Girard College, Philadelphia; res., West Chester, Pa.
HELLMAN, MAXWELL P., Electrical Contractor, Kirby & Hellman, 145 W. 41st St., New York, N. Y.
*HERRING, THOMAS FRANCIS, Sales Representative, The Bristol Co., 832 Frick Bldg., Pittsburgh, Pa.
HERZOG, MAX SAM, Electrical Draughtsman, Stone & Webster, Inc., 147 Milk St., Boston, Mass.
*HOWELL, EDWIN HITE, Requisition Engineer, Transformer Dept., General Electric Co., Ft. Wayne, Ind.
HOWEY, RAYMOND, Field Electrical Engineer, Lehigh Valley Coal Co., Centralia; res., Mt. Carmel, Pa.
*HUNT, SPENCER SHIPLEY, Switchboard Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
*INSKIP, LEONARD S., Instructor, Electrical Engineering Dept., Rensselaer Polytechnic Institute, Troy, N. Y.
JELLEY, ALBERT LEWIS, Electrical Engineer, Nashua Mfg. Co., Nashua Mills, Nashua, N. H.
JENNER, ED., Shop Superintendent, Western Electric Co., Inc., 11th & York Sts., Philadelphia, Pa.
JOHNSON, CHARLES B., General Foreman, Cable Div., Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.
*JONES, S. MURRAY, Engineer, Operating Dept., Alabama Power Co., Birmingham, Ala.
KELLER, CARL C., Electrical Engineer, Cleveland Electric Illuminating Co., 826 Illuminating Bldg., Cleveland, Ohio.
*KENDALL, RALPH MILES, Technical Man, Transmission Engg. Dept., American Tel. & Tel Co., 195 Broadway, New York; for mail, Troy, N. Y.
*KENYON, ALONZO F., General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
*KERSTEN, HAROLD J., Graduate Student of Electrical Engineering, University of Wisconsin, Madison, Wis.
KETCHAM, CHRISTIAN B., Salesmna, Westinghouse Elec. & Mfg. Co., 3rd & Elm Sts., Cincinnati, Ohio.
*KEYS, NEWALL LEROY, Student, School of Engineering of Milwaukee, 415 Marshall St., Milwaukee, Wis.
KING, MILTON EVERETT, Asst. to Supervisor of Witness Test, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
*KINGHORN, ARCHIBALD HENDRIE, JR., Engg. Assistant, Bell Telephone Co., of Penn., 261 N. Broad St., Philadelphia, Pa.
*KITCHEL, ROBERT SANBORN, High Tension Testing Laboratory, Philadelphia Electric Co., 2301 Market St., Philadelphia; res., Ridley Park, Pa.
*KOSITZKY, JAMES CLARENCE, Instructor, Elec. Engg. & Radio Engg. Depts., Oklahoma Agricultural & Mechanical College, Stillwater, Okla.
*KREISHER, CLAUDE, Development Engineer, Western Electric Co., Inc., Hawthorne Sta., Chicago, Ill.
KYNOR, MERRILL WILBER, 454 Conover Terrace, Orange, N. J.
LABADIE, EDWIN F., Junior Electrical Engineer, Fisher Body Corp., General Motors Bldg., Detroit, Mich.
LAMPKIN, CHARLES ALLEN, Switchman, Southern California Telephone Co., 1429 Gower St., Hollywood; res., Los Angeles, Calif.
*LANGFORD, JOHN ALEXANDER, General Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
LAURITSEN, CHARLES CHRISTIAN, Research Engineer, Colin B. Kennedy Corp., 6400 Plymouth Ave., St. Louis, Mo.
*LAZICH, BRANKO, Engg. Assistant, Bell Telephone Co. of Penn., 416-7th Ave., Pittsburgh, Pa.
*LE BOUTILLIER, CHARLES, Student Engr., Bell Telephone Co. of Penn., 261 N. Broad St., Philadelphia; res., Wayne, Pa.
*LECLAIR, TITUS GEORGE, Engineer, Street Dept., Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.
*LEE, BASIL WILFORD, Student Engineer, Testing Dept., General Electric Co., Schenectady, N. Y.
LEEVEN, ALEXANDER A., Asst. to Chief Checker, Survey Bureau, Engg. Div., New York Edison Co., 1439 Inwood Ave., New York, N. Y.
LEONARD, JOHN D., Telephone Engineer, New York Telephone Co., 104 Broad St., New York, N. Y.
LINDSLEY, FLOYD MARTIN, Methods Engineer, Western Elec. Co., Inc., 430 S. Green St., Chicago, Ill.
*LOONEY, JOHN BURROW, Electrical Engineer, 2020 Ave. H., Ensley, Ala.
LUCEY, RICHARD A., Electrical Engineer, Central Aguirre Sugar Co., Central Aguirre, Porto Rico.
LUTZ, E. W., General Manager, The Citizens Telephone Co., 133 N. Court St., Circleville, Ohio.
MACLEAN, GEORGE FREDERICK, Engineer, Auckland Branch, National Electrical & Engineering Co., Ltd., Auckland, N. Z.
*MALTI, MICHEL GEORGE, Instructor of Electrical Engineering, Cornell University, Ithaca, N. Y.
MARSTON, LESTER F., Sales Engineer, Detroit Edison Co., 2000-2nd Blvd., Detroit, Mich.
*MAURAN, JOHN, Operating Dept., Electric Storage Battery Co., 19th & Alleghany Ave., Philadelphia, Pa.
MCBERTY, ZELLA A., Secretary & Treasurer, The Federal Machine & Welder Co., Dana Ave., Warren, Ohio.
MCCLELLAN, ROBERT PHILLIPS, Engineer, Central Station Engg. Dept., General Electric Co., Schenectady, N. Y.
MCDOWELL, ELMER K., Chief Works Engineer, American Steel & Wire Co., Donora Steel Works, Donora, Pa.
*MCHAFFIE, ROY PATERSON, Operator, Winnipeg Electric Railway Co., Great Falls, Man., Can.
MCKINNON, DANIEL ANGUS, Supt. of Transmission, Mexican Light & Power Co., 9a Calle de Luna 254, Mexico City, D. F., Mex.
MCNAMEE, BERNARD FRANCIS, Research Engineer, Colin B. Kennedy Corp., 6400 Plymouth Ave., St. Louis, Mo.
MEIKLE, GEORGE STANLEY, Consulting Industrial Engineer, G. S. Meikle Co., 30 Church St., New York, N. Y.
MESSINGER, EUGENE, Draftsman, General Electric Co., Schenectady, N. Y.
MEYER, KARL A., Electrical Construction Engineer, Lehigh Valley Coal Co., Wilkes-Barre, Pa.
MILLER, GLEN LEON, Engineer, Indiana Bell Telephone Co., 256 N. Meridian St., Indianapolis, Ind.
*MILLER, C. KARLETON, Asst. to Supt. of Electric Generation, Rochester Gas & Electric Corp., 34 Clinton Ave., N., Rochester, N. Y.
MILLER, EARL KEITH, Electrical Engineer, Service Dept., Westinghouse Elec. & Mfg. Co., 9th St. & 2nd Ave., Huntington, W. Va.
*MIMNO, HARRY ROWE, Instructor, Elec. Engg. & Physics, Rensselaer Polytechnic Institute, Troy; res., Pleasantville, N. Y.
*MITCHELL, WILLIAM DOUGLAS, Engineer, American Tel. & Tel. Co., 195 Broadway, New York, N. Y.; res., Ridgewood, N. J.
*MOON, PARRY H., Designer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
*MOONEY, JOHN, JR., Telegraph & Signals Dept., P. T. Div., Pennsylvania R. R., 32nd & Market Sts., Philadelphia, Pa.
MORAN, ROBERT P., Asst. Chief Draftsman, Elec. Engg. Dept., Hudson Coal Co., Scranton, Pa.
MORGANSON, MURRAY A., Elec. Designer, Electric Bond & Share Co., 65-71 Broadway, New York; res., Brooklyn, N. Y.
*MORGENSON, EDGAR O., Tester & Draftsman, Perth Amboy Water Dept., 270 King St., Perth Amboy; res., Woodbridge, N. J.
MOTLEY, JAMES GRIFFIN, Asst. Plant Manager, Western Electric Co., Inc., 463 West St., New York, N. Y.
MUZZILLO, MARIUS, Draughtsman, Survey Bureau, New York Edison Co., Inwood Ave. & 170th St., New York, N. Y.
*NEELY, THOMAS, Gen. Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
NELS, ED., Electrician, Lehigh Portland Cement Co., Oglesby, Ill.
*NEUBERGER, ARTHUR P., Cable Inspector, Public Service Production Co., 15 E. Park St., Newark; res., Netherwood, N. J.
NIELSON, FREDERICK, Electrical Draftsman McClellan & Junkersfeld, 45 William St., New York, N. Y.
NIEMANN, WILLIAM J., Head Draftsman, A. C. Substations, Commonwealth Edison Co., 72 W. Adams St., Chicago, Ill.
*NYGARD, ERIC, Telephone Engg. Dept., Western Electric Co., Inc., 463 West St., New York, N. Y.
OLIVARES, EDWARD, Electrical Engineer, Electromotor Co., Apartado Postal 480, Coyoacan, D. F., Mex.
PAPPAGEORGE, NICHOLAS G., Inspector, Brooklyn Edison Co., 561 Grand Ave., Brooklyn; res., New York, N. Y.
PARKINS, CYRIL LLOYD, Telephone Engineer, Western Electric Co., Inc., 463 West St., New York, N. Y.
*PETERS, E. H., Electrical Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
POLLARD, W. H., Electrical Engineer, Fairbanks, Morse & Co., W. 21st & Northwestern Ave., Indianapolis, Ind.
POLSON, ALEXANDER DAVID, Chief Electrician, Tough Oakes Gold Mine, Kirkland Lake, Ont., Can.
*POOLE, ROBERT E., Instructor, Stevens Institute of Technology, Hoboken; res., West Hoboken, N. J.
POWELL, THOMAS WILLIAMS, Junior Elec. Engineer, Bureau of Power & Light, City of Los Angeles, 140 E. 4th Sts., Los Angeles, Calif.

RACE, HUBERT HAWLEY, Instructor, Electrical Engineering, Cornell University, Ithaca N. Y.
RANDOLPH, ALSTYN F., Asst. to Supt. of Street Dept., Public Service Production Co., 15 E. Park St., Newark; res., New Brunswick, N. J.
*RAUHE, CLINTON H., Electrical Tester, Westinghouse Elec. & Mfg. Co., East Pittsburgh: for mail, Wilkinsburg, Pa.
REID, WILLIAM ALAN, Asst. Field Engineer, Public Service Electric Co., Prospect & Van Houten St., Paterson, N. J.
*REMINE, HAROLD H., Overhead Lines Dept., Detroit Edison Co., Port Huron, Mich.
*RHODES, EARL DELOSS, Sales Engineer, Tolhurst Machine Works, 648 Fulton St., Troy, N. Y.
RING, LESTER L., Statistician, Federal Light & Traction Co., 52 William St., New York, N. Y.
RODGERS, WILLIAM HENRY, General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
RONAY, JULIUS, Engineer-Draftsman, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
ROTH, JOHN WALT, Draughtsman, Pennsylvania Railroad System, Altoona, Pa.
ROYCE, CHARLES FRANKLIN, Research Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh; res., Wilkinsburg, Pa.
ROYS, CARL SHERWOOD, General Electric Test, General Electric Co., Schenectady, N. Y.
RUDD, WILLIAM CHARLES, Associate Engineer, George W. Hubley, 402-403 Norton Bldg., Louisville, Ky.
SCHNYDER, AUXILIUS, Electrical Draftsman, D. P. Robinson Co., 126 E. 46th St., New York, N. Y.
SCHRAMM, RAYMOND F., Electrical Designer, Hudson Coal Co., Scranton, Pa.
*SCHURCH, EDWARD C., Engineer, Contract & Service Dept., General Electric Co., 510 Dwight Bldg., Kansas City, Mo.
SCULLY, ROBERT T., Commercial Engineer, General Electric Co., 18 Asylum St., Hartford Conn.
*SHEALS, VINCENT ALLEN, Electrical Engineer, Central Station Engg. Dept., General Electric Co., Schenectady, N. Y.
SHIMANOVSKY, MARY, 58 W. 127th St., New York, N. Y.
*SHOWERS, CREIGHTON SOLOMON, Student Engineer, Chicago Elevated Railroads, 72 W. Adams St., Chicago, Ill.
SILVERMAN, JACK BERNARD, Electrical Engineer, The Springfield Light, Heat & Power Co., Springfield, Ohio.
*SMITH, IRVING CARLETON, Power Engg. Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
*SMITH, JOHN MOORE, Motor Tester, General Electric Co., Ft. Wayne, Ind.
*SNOOK, HARRY GUILFORD, Construction Dept., General Electric Co., 230 S. Clark St., Chicago; res., Chicago Heights, Ill.
SNYDER, HENRY, General Foreman, Brooklyn Edison Co., 360 Pearl St., Brooklyn, N. Y.
SONTUM, WALTER C., Asst. Engineer, West Penn Power Co., 14 Wood St., Pittsburgh, Pa.
STAHL, BORIS, Draughtsman, Service Bureau, New York Edison Co., New York, N. Y.
STAHL, CHARLES J., Manager, Illuminating Engineering Bureau, Westinghouse Elec. & Mfg. Co., South Bend, Ind.
*STEINBUEHLER, EDWARD A., Asst. Engineer, New York Edison Co., Irving Place & E. 15th St., New York; res., Brooklyn, N. Y.
STEINER, CHARLES LEONARD, JR., Student Engineer, Bell Telephone Co. of Penn., 261 N. Broad St., Philadelphia, Pa.
*STRATFORD, JOHN PAUL, Student, Electrical Engineering Dept., Cornell University, 205 Founders Hall, Ithaca, N. Y.
STRATTON, WILLIAM MERRILL, Student Engineer, Compania Electrica de Alumbrado y Traccion de Santiago, Santiago, Cuba.
SWANSON, EDWIN WALTER, Switchboard Engineer, Electric Machinery Mfg. Co., Minneapolis, Minn.
*TAYLOR, EDMUND RANDOLPH, Radio Engineer, Radio Broadcasting Dept., American Tel. & Tel. Co., 195 Broadway, New York, N. Y.
TAYLOR, HARMON S., Construction Foreman, General Electric Co., 933 Illinois Merchants Bank Bldg., Chicago, Ill.
THAXTON, GUY WERTER, Asst. Professor, Electrical Engineering Dept., Georgia School of Technology, Atlanta, Ga.
TINNEY, FRANCIS B., Electrical Engineer, Wagner Electric Corp., 159 New Montgomery St., San Francisco; res., Palo Alto, Calif.
TOWLE, HARRY STEPHEN, Electrical Operating Engineer, Sanitary District of Chicago, 31st & Western Ave., Chicago, Ill.
*TRAINER, GEORGE T., Pennsylvania Railroad, 17th & Filbert Sts., Philadelphia, Pa.
TURNER, GEORGE EPTHORPE, Engineer in Charge, National Electrical & Engineering Co., Ltd., Dunedin, N. Z.
VINYARD, CURTIS FOUNTAIN, Engg. Assistant, Bell Telephone Co. of Penn., 261 N. Broad St., Philadelphia, Pa.
WADDINGTON, ERIC SUGDEN, Branch Engineer, Hubert Davies & Co., Ltd., Cape Town, S. Africa.
*WALLER, ELWYN, JR., Supply Dept., Crocker-Wheeler Co., Ampere; res., Morristown, N. J.
WALTON, CHARLES STRONG, Manager, General Service Bureau, Southern California Edison Co., Edison Bldg., Los Angeles, Calif.
WASSALL, CLIFFORD G., Engineer, Southwestern Bell Telephone Co., Boatmen's Bank Bldg., St. Louis, Mo.
*WAUGH, JOSEPH T., Electrical Designer, T. E. Murray, Inc., 55 Duane St., New York, N. Y.; res., Philadelphia, Pa.
*WEBB, EDMOND FAULKNER, S. S. Charlton Hall, Isthmian S. S. Line, 39 Cortlandt St., New York: for mail, Tottenville, N. Y.
WEBSTER, WILLIAM CLARKE, Distribution Engineer, Northwestern Electric Co., Pittock Block, Portland, Ore.
*WEIL, ERIC, Inspector, Western Electric Co., Inc., 40 S. 5th Ave., Mt. Vernon; res., Bronx, N. Y.
WESTERVELT, CHARLES SHERWOOD, Electrical Designer, D. P. Robinson & Co., 125 E. 46th St., New York, N. Y.
WHITE, WILLIAM L., President & Chief Engineer, William L. White & Co., 324 Jefferson Co. Bank Bldg., Birmingham, Ala.
WIEDNER, EWALD L., Student, Milwaukee School of Engineering, 700 Marshall St., Milwaukee, Wis.
WILLIAMS, ALLISON RIDLEY, President, Williams & Lebby Engineers Service, Inc., Yazoo City, Miss.
*WOOD, TRUEMAN ANDREW, First Operator, Hydro Power House, Cerro de Pasco Copper Corp., Oroya, Peru, S. A.
YATES, STEPHEN, Engineering Dept., Adirondack Power & Light Corp., Schenectady, N. Y.
YOUNG, RAYMOND ALBERT, Equipment Engineer, Wisconsin Telephone Co., 418 Broadway, Milwaukee; for mail, Wauwatosa, Wis.
*ZAMMATARO, SALVATORE JOSEPH, Electrical Engineer, Western Electric Co., Inc., 463 West St., New York, N. Y.
*ZIMMERMAN, JAMES HAROLD, Division Illuminating Engineer, Pennsylvania Power & Light Co., Williamsport, Pa.

Total 219

*Formerly Enrolled Students.

ASSOCIATES REELECTED JANUARY 18, 1924

BEASLEY, THOMAS E., Elec. Sales Engineer, 619 Bank of Commerce Bldg., St. Louis, Mo.
BRANDENBURGER, LEO, District Manager, Wagner Electric Corp., 419 Dooly Bldg., Salt Lake City, Utah
BRATTLE, WILFRED PERCY, Special Agent, Dept. of Telephones, Parliament Bldgs., Regina, Sask., Can.
WEST, WILLIAM BENJAMIN, Draftsman, Designing Dept., Alabama Power Co., Birmingham, Ala.

MEMBERS ELECTED JANUARY 18, 1924

BROWN, LEWIS RAYMOND, Manager, Transformer Div., Central Station Dept., General Electric Co., Pittsfield, Mass.
CASPER, WILLIAM LEE, Engineer, Western Electric Co., Inc., 463 West St., New York, N. Y.
DAMANT, EDWARD LORRAINE, Senior Lecturer, University of the Witwatersrand, Johannesburg, South Africa.
MORRIS, HARRY W., Appraisal Engineer, Treasury Dept., Washington, D. C.; res., Alexandria, Va.
NANCE, HORACE H., Acting Engineer of Transmission, Long Lines Dept., American Tel. & Tel. Co., 195 Broadway, New York, N. Y.
NYQUIST, HARRY, Telephone Engineer, American Tel. & Tel. Co., 195 Broadway, New York; res., Jackson Heights, N. Y.
ROPER, MARTIN L., General Electrical Foreman, Glen Alden Coal Co., Jefferson Ave. & Linden St., Scranton, Pa.
SKIRROW, JOHN FOSTER, Director, Vice-President, Chief Engineer, Postal Telegraph Cable Co., 253 Broadway, New York, N. Y.
von FABRICE, ROMAN, Designing Engineer, Public Service Production Co., 80 Park Pl., Newark; res., Metuchen, N. J.
WARD, GEORGE C., Vice-President in Charge of Construction & Operation, Southern California Edison Co., Edison Bldg., Los Angeles; res., South Pasadena, Calif.
WEYANDT, C. S., Vice-President, National Electric Mfg. Co., Chatfield-Woods Bldg., Pittsburgh, Pa.
WOLFE, WALLACE V., Telephone Engineer, Western Electric Co., Inc., 463 West St., New York, N. Y.

TRANSFERRED TO GRADE OF FELLOW JANUARY 14, 1924

ALLEN, OLIVER F., Commercial Engineer, International General Electric Co., Schenectady, N. Y.
STICKNEY, GEORGE H., Illuminating Engineering Asst. to Sales Manager, Edison Lamp Works of General Electric Co., Harrison, N. J.

TRANSFERRED TO GRADE OF MEMBER JANUARY 14, 1924

BURLINGHAM, CHARLES S., JR., Business Research Engineer, West Penn Railways Co., Pittsburgh, Pa.
RALSTON, FARLEY C., Research Engineer, Philadelphia Electric Co., Philadelphia, Pa.
TODD, ROBERT I., President and General Manager, Indianapolis Street Railway Co., Indianapolis, Ind.
TOLMAN, CHARLES P., Consulting Engineer, New York, N. Y.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting held January 14, 1924, recommended the following members for transfer to the grades of membership indicated. Any objections to these transfers should be filed at once with the Secretary.

To Grade of Member

BEAN, LESLIE P. R., Electrical Engineer, Sydney, Australia.
FRYER, R. C., Supt. Electric Meters, Union Gas & Electric Co., Cincinnati, O.

GERALD, ARTHUR H., Engineering Assistant Chief Electrician, Pullman Co., Chicago, Ill.

McMASTER, R. K., Electrical Dept., Public Service Production Co., Newark, N. J.

O'DONOHUE, JAMES P., Assistant Chief Engineer, Postal Telegraph Cable Co., New York, N. Y.

PANTON, HARRISON D., Consulting Engineer, Raleigh, N. C.

TASHIMA, YOSHIO, Engineering Division, Stone & Webster, Boston, Mass.

THOMAS, PHILLIPS, Research Engineer, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.

TOWLE, NORMAN L., In charge of Electrical Laboratories, Cooper Union, New York, N.Y.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a higher grade than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before February 29, 1924.

Ager, R. W., So. California Edison Co., Los Angeles, Calif.
Alverson, G. S., Rochester Gas & Electric Corp., Rochester, N. Y.
Allain, G. O., Jr., Cumberland Tel. & Tel. Co., Nashville, Tenn.
Andrews, J. L., Union Gas & Electric Co., Cincinnati, Ohio
Arcaute, J. A., The New York Edison Co., New York, N. Y.
Azovsky, Z., Adirondack Power & Light Co., Rotterdam, N. Y.
Bardwell, H. F., Westinghouse Elec. & Mfg. Co., E. Springfield, Mass.
Barnsdale, G. H., Pacific Tel. & Tel. Co., Los Angeles, Calif.
Bartley, E. W., Century Electric Co., New York, N. Y.
Bee, E. S., State Sanatorium, Sanatorium, Miss.
Beede, C. H., City Lighting Dept. of Seattle, Seattle, Wash.
Beeth, W. G., General Electric Co., Ft. Wayne, Ind.
Bhushan, V., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Binz, W. C. (Member), The United Gas Improvement Co., Philadelphia, Pa.
Bishop, G. M., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Bonn, A. E., A. E. Bonn & Co., Inc., New York, N. Y.
Bossart, P. N., Willard Storage Battery Co., Cleveland, Ohio
Bowers, B. N., General Electric Co., Schenectady, N. Y.
Briggs, W. P., (Member), Inspector of Wires, Municipal Bldg., New Bedford, Mass.
Brinckerhoff, H. F., Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.
Broadhead, A. P., (Member), N. Y. State Gas & Elec. Corp., Oneonta, N. Y.
Buchanan, D. L., Philadelphia Sub. Gas & Electric Co., Wyancote, Pa.
Buchanan, O. B., (Member), Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Buff, C. T., Electric Bond & Share Co., New York, N. Y.
Buhl, C. H., Ohio Bell Telephone Co., Cleveland, Ohio
Burke, A. C., Dealer & Mfgr., X-Ray Apparatus, Toronto, Ont.
Burkett, B. B., Westinghouse Elec. & Mfg. Co., Seattle, Wash.
Butterfield, L. B., Western Electric Co., Inc., Chicago, Ill.
Cantlen, J. S., Pacific Tel. & Tel. Co., San Francisco, Calif.
Carmichael, E. T., New York Edison Co., New York, N. Y.
Castro-Gamboa, F., New York Edison Co., New York, N. Y.
Chapman, H. H., Halcomb Steel Co., Syracuse, N. Y.
Chase, J. S., Illinois Bell Telephone Co., River Forest, Ill.
Chombliss, H. E., Montana Power Co., Great Falls, Mont.
Christian, C. J., Western Electric Co., Philadelphia, Pa.
Clark, H. A., Consolidated Gas, Elec. Lt. & Pr. Co., Baltimore, Md.
Clark, H. F., General Motors Research Corp., Dayton, Ohio
Clark, J. A., Brooklyn Edison Co., Brooklyn, N. Y.
Clark, J. A., Independent Electric Co., Minneapolis, Minn.
Clarke, C. A., Western Electric Co., Inc., New York, N. Y.
Cloutier, L. P., Singer Mfg. Co., St. Louis, Mo.
Cook, W. E., Wadsworth Brick & Tile Co., Wadsworth, Ohio
Cooper, A. J., Allis-Chalmers Mfg. Co., New York, N. Y.
Copicott, J. V., Dubilier Condenser Co., New York, N. Y.
Coughlan, A. M. J., Brooklyn Edison Co., Brooklyn, N. Y.
Covell, M. E., Jr., Detroit Edison Co., Detroit, Mich.
Cowley, F. C., Puget Sound Power & Light Co., Seattle, Wash.
Crapo, F. M., Indiana Steel & Wire Co., Muncie, Ind.
Crawford, W. McK., New York Edison Co., New York, N. Y.
Crooks, H., Allis-Chalmers Mfg. Co., West Allis, Wis.
Crossley, H., Portland Ry., Lt. & Power Co., Portland, Ore.
Crothers, F. A., Union Electric Steel Corp., Carnegie, Pa.
Crow, R. M., Kansas City Power & Light Co., Kansas City, Mo.
Crowley, J. C., Western Electric Co., New York, N. Y.
Cunningham, J., Bell Tel. Co. of Pa., Philadelphia, Pa.
Curley, M. H., Sterling Salt Co., Cuylerville, N. Y.
Dagen, C. F., Utica Gas & Electric Co., Utica, N. Y.
Dale, I. H., Western Electric Co., New York, N. Y.
Dalton, A. G., Western Electric Co., Inc., New York, N. Y.
Davis, C. C., (Member), Village Electric Dept., Northfield, Vt.
Day, E. H., Standard Underground Cable Co., Philadelphia, Pa.
Dean, A. L., Philadelphia Electric Co., Philadelphia, Pa.
Deaville, E., Hydro-Elec. Pr. Commission, Toronto, Ont.
de Dekam, F. J., (Member), Dwight P. Robinson & Co., New York, N. Y.
de Puy, M. J., Brooklyn Edison Co., Brooklyn, N. Y.
Deeds, E. F. M., Victor X-Ray Corp., Kansas City, Mo.
Dickinson, J. M., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Dingledine, R. K., Tennessee Inspection Bureau, Nashville, Tenn.
Dobson, C. F., Wisconsin Power, Light & Heat Co., Madison, Wis.
Dunkle, W. F., Union Gas & Electric Co., Cincinnati, Ohio
Eder, F., (Member), Robert W. Hunt Co., New York, N. Y.
Emmons, W. M., Westinghouse Elec. & Mfg. Co., Atlanta, Ga.
Engelke, L. J., U. S. Naval Academy, Annapolis, Md.
Farquhar, H., General Electric Co., Seattle, Wash.
Fentnor A W. New York Edison Co., New York, N. Y.
Finley, H. R., Western Union Telegraph Co., Boston, Mass.
Finn, J. J., R. T. Oakes Co., Holyoke, Mass.
Flutsch, L., C. M. & St. P., Railway Co., Milwaukee, Wis.
Forner, S., Commonwealth Edison Co., Chicago, Ill.
Foulke, W. B., Wagner Electric Corp., Philadelphia, Pa.
Fowler, H. M., Westinghouse Elec. & Mfg. Co., Seattle, Wash.
Frame, F. H., Worcester Polytechnic Institute, Worcester, Mass.
Freisen, E. C., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Fuchs, G. W., Philadelphia Electric Co., Philadelphia, Pa.
Gallup, C. M., The Ohio Bell Telephone Co., Cleveland, Ohio
Gay, H. L., Westinghouse Elec. & Mfg. Co., St. Louis, Mo.
Gillespie, G. S., (Member), Westinghouse E. & M. Co., Kansas City, Mo.
Goldsborough, S. L., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Goldstone, P., (Member). Gibbs & Hill, New York, N. Y.
Gower, A. G., Jr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Graham, H. C., Ferranti Meter & Transformer Mfg. Co., Toronto, Ont.
Grange, F. D., Adirondack Power & Light Corp., Schenectady, N. Y.
Grantham, R. E., City Lighting Dept. of Seattle, Seattle, Wash.
Gray, R., Bell Telephone Co. of Canada, Toronto, Ont.
Gray, V. D., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Gray, W. B., New England Tel. & Tel. Co., Boston, Mass.
Gray-Donald, E., Toronto Hydro-Electric System, Toronto, Ont.
Grim, C. D., J. G. White Engg. Corp., Pottsville, Pa.
Grimes, R. L., The Jefferson Coal Co., Piney Fork, Ohio
Grosse, A. W., Western Electric Co., Inc., Cleveland, Ohio
Groves, G. R., Western Electric Co., Inc., New York, N. Y.
Gurley, L. S., Pacific Tel. & Tel. Co., San Francisco, Calif.
Hagstad, A., Interborough Rapid Transit Co., New York, N. Y.
Hardy, R. C., General Electric Co., Schenectady, N. Y.
Harper, S., Pratt Institute, Brooklyn, N. Y.
Haskins, L. E., New England Tel. & Tel. Co., Boston, Mass.
Hatchett, R. T., Allen-Bradley Co., New York, N. Y.
Haymond, E. S., (Member), West Penn Power Co., Pittsburgh, Pa.
Hayward, A. E., Toronto Hydro-Electric System, Toronto, Ont.
Heinrich, H. W., (Member), Travelers Insurance Co., Hartford, Conn.
Heitzler, A. H., (Member), The Ohio Public Service Co., Elyria, Ohio
Hendricks, C. I., New Orleans Public Service, Inc., New Orleans, La.
Henny, G. C., Western Electric Co., Inc., New York, N. Y.
Hodge, D., Worcester Electric Light Co., Worcester, Mass.
Hoffman, R. W., Western Electric Co., Inc., New York, N. Y.
Hornbager, E. H., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Hubbell, H. L., Royal Indemnity Co., New York, N. Y.
Husta, P., Western Electric Co., Inc., New York, N. Y.

Jenkins, G. S., Consolidated Coal Co., St. Louis, Mo.
Jenne, H. E., New York Telephone Co., New York, N. Y.
Johnson, L. W., Brooklyn Edison Co., Brooklyn, N. Y.
Jones, D. O., Western Electric Co., Inc., New York, N. Y.
Kamp, D., Philadelphia Electric Co., Philadelphia, Pa.
Keiter, F. W., Jr., Electro Therapeutic Laboratory, Philadelphia, Pa.
Kellams, W. W., Westinghouse Elec. & Mfg. Co., Kansas City, Mo.
Kelsey, A. J., New York Edison Co., New York, N. Y.
Kettering, W. H., Public Service Co. of No. Illinois, Chicago, Ill.
Kipp, K., 432, 36th St., New York, N. Y.
Klep, M., United Elec. Light & Power Co., New York, N. Y.
Knecht, V. C., Maxwell Motor Corp., Detroit, Mich.
Kneisel, F. C., The Braun Co., Philadelphia, Pa.
Kraft, J. T., Atlantic City Electric Co., Atlantic City, N. J.
Kuhn, H. H., (Member), Kansas City Power & Light Co., Kansas City, Mo.
Kurlander, J. H., Edison Lamp Works, Harrison, N. J.
Lackland, R. E., American Tel. & Tel. Co., Chicago, Ill.
Lane, J. C., California Oregon Power Co., Medford, Ore.
Lang, T. R., Hydro-Electric Power Commission, Toronto, Ont.
Langum, T. N., Wisconsin Power, Light & Heat Co., Madison, Wis.
Larsson, K. J., Boustead Electric & Mfg. Co., Minneapolis, Minn.
Lee, C. F., General Electric Co., Schenectady, N. Y.
Lee, L. H., Lake Cushman Project, Tacoma, Wash.
Lent, R. C., Jr., New York Fire Dept., New York, N. Y.
Levy, J., 1042 45th St., Brooklyn, N. Y.
Lincoln, A. W., Bell Telephone Co. of Pa., Philadelphia, Pa.
Lindsay, S. C., (Member), Puget Sound Power & Light Co., Seattle, Wash.
Loewenberg, C. O., Cleveland Railway Co., Cleveland, Ohio
Lurie, B. J., C. B. Fall Co., St. Louis, Mo.
Lutz, E. R., Bel. Telephone Co. of Pa., Philadelphia, Pa.
Mabery, H. L., Erie Lighting Co., Erie, Pa.
Mackay, W. M., Electrician, King Edward Hotel, Toronto, Ont.
Maldonado, J., Weston Electrical Instrument Co., Newark, N. J.
Malloch, C. D., Consumers Power Co., Jackson, Mich.
Malone, L. J., New England Tel. & Tel. Co., Boston, Mass.
Manor, G. L., Washington Water Power Co., Post Falls, Idaho
Martin, I. C., Woodward Governor Co., Rockford, Ill.
Mason, G. U., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
McCullough, H. G., New York Edison Co., New York, N. Y.
McGrath, J. R., Northern Electric Co., Ltd., Montreal, Quebec
McKee, C. W., Harrisburg Mechanical School, Harrisburg, Pa.
McKelvey, R. S., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
McLaughlin, H. A., Brooklyn Edison Co., Brooklyn, N. Y.
McLemore, J. R., Westinghouse E. & M. Co., E. Pittsburgh, Pa.
McMurray, T. H., Pacific Tel. & Tel. Co., San Francisco, Calif.
McNamara, F. T., Yale University, New Haven, Conn.
McReynolds, L. R., Brooklyn Edison Co., Brooklyn, N. Y.
Melnick, P. F., So. California Edison Co., Long Beach, Calif.
Merrill, O. C., (Member), Federal Power Commission, Washington, D. C.
Merritt, J. C., Shawinigan Water & Power Co., Shawinigan Falls, P. Q.
Metz, L. C., Bell Tel. Co. of Pa., Philadelphia, Pa.
Millen, H. A., Brooklyn Edison Co., Brooklyn, N. Y.
Miller, J., Public Service Production Co., Newark, N. J.
Mitchell, E. H., Brooklyn Edison Co., Brooklyn, N. Y.
Monk, E. D., General Electric Co., Cincinnati, Ohio
Mooers, B. C., Lighting Dept., City of Seattle, Seattle, Wash.
Mooney, F. P., S. California Edison Co., Redlands, Calif.
Morey, I., Westinghouse Elec. & Mfg. Co., Kansas City, Mo.
Mortenson, J. P., New York Telephone Co., New York, N. Y.
Murphy, A. L., Worcester Electric Light Co., Worcester, Mass.
Nahrgang, A. R., Western Electric Co., Inc., Chicago, Ill.
Nelson, C. E., Highland Ave., Flushing, N. Y.
Newman, A. M., Atlantic City Electric Co., Atlantic City, N. J.
Nienstedt, H. B., Western Electric Co. Inc., New York, N. Y.
O'Malley, C. T., New England Tel. & Tel. Co., Boston, Mass.
Ordan, L. S., American Gas & Electric Co., New York, N. Y.
Ortega, A. F., Westinghouse International Co., Mexico, D. F., Mex.
Osborn, C. F., American Car & Foundry Co., St. Louis, Mo.
Otto, G. R., New York Edison Co., New York, N. Y.
Parrish, J. S., Maxwell Motor Corp., Detroit, Mich.
Parsons, C. V., Parsons Electric Co., Puyallup, Wash.
Patterson, H. S., W. Ames & Co., Jersey City, N. J.
Pause, H. A., Tri-State Tel. & Tel. Co., St. Paul, Minn.
Payne, E. C., Westinghouse Elec. & Mfg. Co., Detroit, Mich.
Pearson, F. L., Otis Elevator Co., Yonkers, N. Y.
Perry, A. W., Brooklyn Edison Co., Brooklyn, N. Y.
Pieper, H., New York Telephone Co., New York, N. Y.
Pierce, C. E., The Pacific Tel. & Tel. Co., Los Angeles, Calif.
Pierce, C. G., Iowa Electric Motor Service, Des Moines, Iowa
Platt, H. M., Ford Instrument Co., Long Island City, N. Y.
Plenge, H. D., General Electric Co., Schenectady, N. Y.
Price, F. M., So. California Edison Co., Big Creek, Calif.
Pringle, Arthur E., (Member), Pringle Electric Mfg. Co., Philadelphia, Pa.
Quinlan, A. L., Western Electric Co., Inc., Hawthorne, Ill.
Radlund, J. S., Jr., Wisconsin River Power Co., Prairie du Sac, Wis.
Ralph, A. H., 67 Arlington Ave., Brooklyn, N. Y.
Reisinger, H. B., George F. Motter's Sons, York, Pa.
Reppert, G. H., Otis Elevator Co., New York, N. Y.
Reukema, L. E., University of California, Berkeley, Calif.
Reutlinger, F. J., Jr., Bell Tel. Co. of Pa., Philadelphia, Pa.
Reynolds, F. L., Rochester Gas & Electric Corp., Rochester, N. Y.
Robbins, G. P., Jr., General Electric Co., Schenectady, N. Y.
Roberts, I. C., Portland Ry., Lt. & Power Co., Portland, Ore.
Robinson, B. S., Philadelphia Electric Co., Philadelphia, Pa.
Robson, N. O., Mountain States Tel. & Tel. Co., Denver, Colo.
Rosenberg, I. M., 108 Fulton St., New York, N. Y.
Rossel, L. E., Westinghouse Elec. & Mfg. Co., Wilkinsburg, Pa.
Roters, H. C., Stevens Inst. of Technology, Hoboken, N. J.
Rowell, R. R., Utah Power & Light Co., Salt Lake City, Utah
Rusch, H. L., University of Wisconsin, Madison, Wis.
Russell, C., North Coast Power Co., Chehalis, Wash.
Russell, S. P., H. B. Squires Co., San Francisco, Cal.
Ryden, E. H., Western Electric Co., Inc., New York, N. Y.
Samuels, M. M., (Fellow), J. G. White Engg. Corp., New York, N. Y.
Saunders, A. W., Western Electric Co., Inc., New York, N. Y.
Savage, A. H., Union Public Service Co., St. Paul, Minn.
Schelkunoff, S. A., Western Electric Co., Inc., New York, N. Y.
Schlapfer, G. L., New York Telephone Co., New York, N. Y.
Schlotterbeck, P. G., Utah Power & Light Co., Grace, Idaho
Schroeder, A. E., Western Electric Co., Inc., Chicago, Ill.
Schwyter, E. M., Wilmington High School, Wilmington, Del.
Shippy, V., Central High School, Philadelphia, Pa.
Simpson, A. L. F., 24 E. Mount Ave., Toronto, Ont.
Simpson, B. G., Bell Telephone Co. of Pa., Philadelphia, Pa.
Simpson, W. O., Diehl Mfg. Co., Elizabeth, N. J.
Smith, C. S., Jr., Pacific Tel. & Tel. Co San Francisco, Calif.
Soderbaum, C. E., Commonwealth Edison Co., Chicago, Ill.
Sordoni, A. J., General Contractor, Forty Fort, Pa.
Sommerfeld, S., Brooklyn Edison Co., Inc., Brooklyn, N. Y.
Squires, H. A., Union Gas & Electric Co., Cincinnati, Ohio
Stauffer, J. L., Edison Electric Co., Lancaster, Pa.
Stehlik, R. F., Automatic Electric Co., Chicago, Ill.
Steinberg, M. J., Brooklyn Edison Co., Brooklyn, N. Y.
Stern, E., (Member), Schuylkill Railway Co., Girardville, Pa.
Stevens, W. E., Western Electric Co., Inc., New York, N. Y.
Stevens, W. L., Smith Robinson & Co., Vancouver, B. C.
Stults, R., Commonwealth Edison Co., Chicago, Ill.
Sommerfeld, S., Brooklyn Edison Co., Brooklyn, N. Y.
Sullivan, T. J., Nichols Copper Co., Laurel Hill, N. Y.
Summers, I. H., General Electric Co., Schenectady, N. Y.
Swanson, D. H., Philadelphia Suburban Gas & Elec. Co., Wyncote, Pa.
Sweeny, C. P., *U. S. S. Modoc*, C. G., Angelton, Texas
Tate, T. R., (Member), McClellan & Junkersfeld, New York, N. Y.
Teach, F. A., Dept. of Bldg. Regulation, City of Columbus, Columbus, Ohio
Thrisk, G. T., (Member), Elec. Engr. & Contractor, Seattle, Wash.
Thornburg, H. A., Remey Electric Co., Anderson Ind.

Tirrell, R. P., Western Electric Co., New York, N. Y.
Todaro, I., New York Edison Co., New York, N. Y.
Turnbull, W. D., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Tykociner, J. T., University of Illinois, Urbana, Ill.
Underwood, P. H., Rice Institute, Houston, Texas
Van Etten, G. W., General Electric Co., Schenectady, N. Y.
Vine, E. L., Brooklyn Edison Co., Brooklyn, N. Y.
Vrla, R. R., Rochester Gas & Electric Corp., Rochester, N. Y.
Wald, G. E., Radio Recepter Co., Inc., New York, N. Y.
Walther, L. A., American Tel. & Tel. Co., New York, N. Y.
Watrous, J. F., Westinghouse Elec. & Mfg. Co., Kansas City, Mo.
Webber, T. G., United Elec. Railways Co., Providence, R. I.
Westerfield, E. H., Jr., 15 E. 125th St., New York, N. Y.
Wilburn, J. C., International General Electric Co., Schenectady, N. Y.
Wing, H. O., New England Tel. & Tel. Co., Boston, Mass.
Wintermute, H. A., (Member), Research Corp., Bound Brook, N. J.
Wohle, M. J., M. J. Wohle & Co., Inc., Long Island City, N. Y.
Worth, J. B., Western Electric Co., Inc., New York, N. Y.
Wurgel, R. A., Western Electric Co., Inc., New York, N. Y.
Wylie, W. J., Toronto Hydro-Elec. System, Toronto, Ont.
Xenakis, J., (Member), 493, 3rd Ave., New York, N. Y.
Ziegler, E. S., Westinghouse Elec. & Mfg. Co., Huntington, W. Va.
Total 276

Foreign

Axon, A. E., Metropolitan Vickers Electrical Co., Ltd., Trafford Park, Manchester, Eng.
Barrere, M., with M. M. Schneider & Co., Paris, France
Hegarzy, H. M., Egyptian Public Works Ministry London, Eng.
Hopper, E. S., Braden Copper Co., Rancagua, Chile, S. A.
Mathur, R. L., Public Works Dept., Raisina, Delhi, India
Matthewson, F., Southland Hydro-Elec. Pr. Board, Invercargill, N. Z.
Metzger, H. A., Andian National Corp., Ltd., Cartagena, Colombia, S. A.
Paton, N. A., Westinghouse Elec. International Co., London, Eng.
Santuari, E., Societa Generale Elettrica Tridentina, Bolzano, Alto Adige, Italy
Sutherland, R. A., Dunedin City Corp., Dunedin, N. Z.
Sychra, S., Ceskomoravska-Kolben Co., Prague-Vysocany, Czechoslovakia
Velander, S., Power Co. of South Sweden, Malmo, Sweden
Total 8

STUDENTS ENROLLED JANUARY 18, 1924

18341 Vanderlip, Arthur L., Newark Technical School
18342 Perkins, Harold D., Univ. of California
18343 Farrar, Walter B., University of Kansas
18344 Rose, G. Edmund, University of Kansas
18345 Heinrich, John, University of Kansas
18346 Tucker, Clyde E., University of Kansas
18347 Mills, Neil, University of Kansas
18348 Walker, Theodore S., Stanford University
18349 Lissman, Marcel A., Stanford University
18350 Benson, Cecil R., Stanford University
18351 Crever, Fred E., Stanford University
18352 English, Harlow, Jr., Stanford University
18353 Dickenson, Charles Wm., Stanford University
18354 Booth, Robinson E., Stanford University
18355 Hesselmyer, Clarence T., Stanford University
18356 Fullerton, Dick P., Jr., Stanford University
18357 Becker, Arthur W., Stanford University
18358 Cook, Robert C., Stanford University
18359 Goldstein, David J., Case School of Applied Science
18360 Gimmy, Norman H., Case School of Applied Science
18361 Berry, De Lohr, University of Michigan
18362 Warner, Seward A., University of Michigan
18363 Lee, William J., University of Michigan
18364 Broom, Albert, University of Michigan
18365 Chapman, Everett, University of Michigan
18366 Lloyd, Morris H., University of Michigan
18367 Katz, Maxwell, University of Michigan
18368 Trevino, Rodolfo R., University of Notre Dame
18369 Cazandjian, Rouel G., Columbia University
18370 Swazey, Hollis A., Villanova College
18371 Fridlund, Reuben P., State College of Washington
18372 Tomaino, Felix F., Yale University
18373 Sullivan, Robert J., Northeastern Univ.
18374 Styner, Percy M., University of Idaho
18375 Holloway, John P., Montana State College
18376 Hampshire, Benjamin F., Mass. Institute of Technology
18377 Fisher, Alvan, Mass. Institute of Tech.
18378 Fowble, Gerald, University of Nevada
18379 Shaber, Neil B., University of Nevada
18380 Harrison, Arthur T., University of Nevada
18381 Shafer, Hal J., Ohio Northern University
18382 Otis, John P., Johns Hopkins University
18383 Peterson, Lloyd E., Iowa State College
18384 Hulse, Herbert H., Iowa State College
18385 Metz, Neil, Iowa State College
18386 Burkett, Albert, Iowa State College
18387 Page, Stuart G., Iowa State College
18388 Smith, Clarence H., Iowa State College
18389 Reed, Russel A., Iowa State College
18390 Thorson, Wilbur R., Iowa State College
18391 Koschmeder, Louis A., Iowa State College
18392 Womeldorff, Virgil L., Iowa State College
18393 Miller, William McK., Iowa State College
18394 Barker, William E., Iowa State College
18395 Peterson, Lawrence J., Iowa State College
18396 Wilkinson, Roger I., Iowa State College
18397 Samoiloff, Leon A., Harvard University
18398 Barone, Nick, West Virginia University
18399 Fearn, Ellsworth E., Univ. of Nebraska
18400 Bowles, Charles H., Mass. Institute of Technology
18401 Pahren, Herbert S., Univ. of Cincinnati
18402 Reite, Arthur E., Univ. of North Dakota
18403 Lunas, Lawrence J., Univ. of North Dakota
18404 Ogden, Aubrey B., Univ. of North Dakota
18405 Gilhooly, John E., Univ. of North Dakota
18406 Frank, Leo C., University of North Dakota
18407 Dhar, Matilal, University of Illinois
18408 Jardine, Ray, University of Illinois
18409 Griffin, Clyde M., Ohio State University
18410 Bidlack, Cecil S., Ohio State University
18411 Griffin, George A., Ohio State University
18412 Thurston, Howard A., Ohio State Univ.
18413 Higgy, Robert C., Ohio State University
18414 Florl Russell T., Ohio State University
18415 Fisher, Robert H., Ohio State University
18416 Lincoln, William C., Ohio State University
18417 Rayburn, C. Max, Ohio State University
18418 Heeb, Irving A., Ohio State University
18419 Stanbery, Jennings N., Ohio State Univ.
18420 Duvall, Ralph J., University of Kansas
18421 Wolf, Oswald G., University of Texas
18422 Hengy, George C., University of Texas
18423 Wilkinson, Claude K., State University of New Mexico
18424 Curtis, George V., University of Idaho
18425 Saliba, George J., Northeastern University
18426 Sullivan, Edward S., University of Notre Dame
18427 Carothers, Archie D., Mass. Institute of Technology
18428 Crider, Frank B., Johns Hopkins Univ.
18429 Eschbach, Donald O., Bucknell University
18430 Kooke, Charles A., Johns Hopkins Univ.
18431 Weeks, Walter R., Mass. Institute of Tech.
18432 Holman, John L., University of New Brunswick
18433 Pearce, Cullen T., University of New Mex.
18434 Knight, Lawrence T., University of Colorado
18435 Burton, John T., University of Notre Dame
18436 Perkins, Eustace J., Northeastern Univ.
18437 Grabar, John, Columbia University
18438 Burdick, Ralph L., Oregon Institute of Technology
18439 Corbett, Howard E., Oregon Institute of Technology
18440 Hamilton, Robert F., Oregon Institute of Technology
18441 McCann, E. Earl, Oregon Institute of Technology
18442 Pringle, Lester C., Oregon Institute of Technology
18443 Schroeder, A. Frank, Oregon Institute of Technology
18444 Tucker, Everett L., Oregon Institute of Technology
18445 Walters, Louis G., Oregon Institute of Technology
18446 Kelley, David, Drexel Institute
18447 Mackin, Leonard E., Drexel Institute
18448 Skorochod, I. Louis, Drexel Institute
18449 Steward, Owen F., Drexel Institute
18450 Stanton, Lester C., Bucknell University
18451 Speed, Russell B., Brooklyn Polytechnic Institute
18452 Bruce, Edmond, Mass. Institute of Tech.
18453 Small, Carl R., University of Nevada
18454 Tyson, Loring E., Brooklyn Polytechnic Institute
18455 Harmel, Robert L., Cooper Union
18456 Goodman, Aldolph, Syracuse University
18457 Takahara, Hidemi, University of Nebraska
18458 Cobb, Philip G., Newark Technical School
18459 Graley, Henry H., Syracuse University
18460 Swank, Lawrence N., Pennsylvania State College
18461 Bush, Herbert L., Colorado State Agricultural College
18462 Truesdell, Willard M., Colorado State Agricultural College
18463 Rasmussen, Walter, Colorado State Agricultural College
18464 Smith, Ezra, D., Colorado State Agricultural College
18465 Brooks, Louis, University of Denver
18466 Dove, Archie H., University of Denver
18467 Schumann, Kenneth B., University of Denver
18468 Hooper, William H., University of Denver
18469 Kuhler, Ralph L., University of Denver
18470 Reed, Earl, University of Denver
18471 Silver, Ronald A., University of Denver
18472 Larnach, Donald W. P., Stanford Univ.
18473 Bramble, Ernest M., Stevens Institute of Technology
18474 Keen, S. Craig, Mass. Institute of Tech.
18475 Maier, William F., Northeastern Univ.
18476 Larson, Edward S., Armour Institute of Technology
18477 Meyer, Edwin M., Armour Institute of Technology
18478 Schroeder, John H., Armour Institute of Technology
18479 Sothen, William H., Armour Institute of Technology
18480 Taylor, George J., Armour Institute of Technology
18481 Wilson, Harrison D., Jr., Armour Institute of Technology
18482 Adkins, Alonza H., Virginia Military Institute
18483 Hubbard, Beverly R., Mass. Institute of Technology
18484 Thomson, John Morton, University of Toronto
18485 Urner, Martin J., Johns Hopkins Univ.
18486 Emerson, John W., Ohio State University
18487 Ward, James H., Jr., Univ. of Tennessee
18488 Kopp, Bernard J., Northeastern University
18489 Keins, Harold H., University of Minnesota

18490 Keil, M. Theodore, Jr., Brooklyn Polytechnic Institute
18491 Logan, T. Joseph, Johns Hopkins University
18492 Frank, Gerald M., Mass. Institute of Technology
18493 Peck, Ottway, University of Nevada
18494 Otto, Eric C., University of Nevada
18495 Haldeman, Ralph A., Lafayette College
18496 Sawyer, Gordon W., University of Southern California
18497 Groot, Carl B., University of Southern California
18498 Severns, Walter E., University of Southern California
18499 Payne, Earl C., University of Southern California
18500 Becker, Henry A., Ohio State University
18501 Johnson, Robert R., Ohio State University
18502 Ahrling, George A., Stevens Institute of Technology
18503 McBrayer, Walter R., Univ. of Colorado
18504 Bernreuter, Herbert A., Univ. of Illinois
18505 Woods, John P., University of Texas
18506 Heye, Oscar W., University of Texas
18507 Hearn, George C., University of Texas
18508 Burks, Guy, University of Texas
18509 Scoggins, Monroe, Oklahoma A. & M. College
18510 Woodyard, Kenneth C., Oklahoma A. & M. College
18511 Twidwell, Ralph W., Oklahoma A. & M. College
18512 Wrigley, Robert C., Oklahoma A. & M. College
18513 Riddle, Roy F., Oklahoma A. & M. College
18514 Cermak, Wesley E., Oklahoma A. & M. College
18515 Whitman, Ohir R., Oklahoma A. & M. College
18516 Long, Eldon A., Stanford University
18517 Wilcox, Clarendon W., University of Wisconsin
18518 MacLafferty, Taylor W., Washington State College
18519 Walker, Hugh L., Mass. Institute of Technology

Total 179

OFFICERS OF A. I. E. E. 1923-1924

President
Harris J. Ryan

Junior Past-Presidents
Frank B. Jewett — William McClellan

Vice-Presidents
W. I. Slichter — J. E. Macdonald
R. F. Schuchardt — Herbert S. Sands
H. T. Plumb — S. E. M. Henderson
G. Faccioli — H. E. Bussey
H. W. Eales — William F. James

Managers
Harold B. Smith — H. M. Hobart
James F. Lincoln — Ernest Lunn
E. B. Craft — G. L. Knight
R. B. Williamson — William McConahey
A. G. Pierce — W. K. Vanderpoel
Harlan A. Pratt — H. P. Charlesworth

Treasurer
George A. Hamilton

Secretary
F. L. Hutchinson

Honorary Secretary
Ralph W. Pope

LOCAL HONORARY SECRETARIES

Carroll M. Mauseau, Caixa Postal No. 571, Rio de Janeiro, Brazil
Charles le Maistre, 28 Victoria St., London, S. W., England
A. S. Garfield, 45 Bd. Beausejour, Paris 16 E, France
H. P. Gibbs, Tata Sons, Ltd., Navsari Building, Fort Bombay, India
Guido Semenza, 39 Via Monte Napoleone, Milan, Italy
Lawrence Birks, Public Works Department, Wellington, New Zealand
Axel F. Enstrom, 24 A Grefturegatan, Stockholm, Sweden
W. Elsdon-Dew, P. O. Box 4563, Johannesburg, Transvaal, Africa

A. I. E. E. COMMITTEES

(A list of the personnel of Institute committees may be found in the January issue of the Journal and will be published again in the June issue.)

GENERAL STANDING COMMITTEES AND CHAIRMEN

Executive, Harris J. Ryan
Finance, G. L. Knight
Meetings and Papers, L. W. W. Morrow
Publication, Donald McNicol
Coordination of Institute Activities, W. I. Slichter
Board of Examiners, H. H. Norris
Sections, A. W. Berresford
Student Branches, C. E. Magnusson
Membership, M. E. Skinner
Headquarters, E. B. Craft
Law, H. H. Barnes, Jr.
Public Policy, H. W. Buck
Code of Principles of Professional Conduct, John W. Lieb
Safety Codes, H. B. Gear
Standards, H. S. Osborne
Edison Medal, Edward D. Adams

SPECIAL COMMITTEES

Columbia University Scholarship, Francis Blossom
Award of Institute Prizes, L. W. W. Morrow

TECHNICAL COMMITTEES AND CHAIRMEN

Educational, W. E. Wickenden
Electrical Machinery, H. M. Hobart
Electrochemistry and Electrometallurgy, J. L. Yardley
Electrophysics, F. W. Peek, Jr.
Industrial and Domestic Power, H. D. James
Instruments and Measurement, G. A. Sawin
Iron and Steel Industry, F. B. Crosby
Lighting and Illumination, G. H. Stickney
Marine, G. A. Pierce
Mines, F. L. Stone
Power Stations, Nicholas Stahl
Protective Devices, H. R. Woodrow
Research, John B. Whitehead
Telegraphy and Telephony, O. B. Blackwell
Traction and Transportation, N. W. Storer
Transmission and Distribution, F. G. Baum

A. I. E. E. REPRESENTATION

(The Institute is represented on the following bodies; the names of the representatives may be found in the January issue of the Journal and will be published again in the June issue.)

Council of the American Association for the Advancement of Science
American Bureau of Welding
American Committee on Electrolysis
American Engineering Council of the Federated American Engineering Societies
American Engineering Standards Committee
Apparatus Makers and Users Committee
Board of Trustees, United Engineering Society
Charles A. Coffin Fellowship and Research Fund Committee
Engineering Foundation Board
International Engineering Congress, Philadelphia 1926, Board of Management
John Fritz Medal Board of Award
Joint Conference Committee of Four Founder Societies
Library Board, United Engineering Society
National Fire Protection Association, Electrical Committee
National Fire Waste Council
National Research Council, Engineering Division
Society for the Promotion of Engineering Education, Board of Investigation and Coordination
U. S. National Committee of the International Illumination Commission
U. S. National Committee of the International Electrotechnical Commission
Commission of Washington Award

LIST OF SECTIONS

Name	Chairman	Secretary
Akron	P. C. Jones	C. D. Black, B. F. Goodrich Co., Akron, Ohio
Atlanta	C. L. Emerson	H. N. Pye, Box 1743, Atlanta, Ga.
Baltimore	W. B. Kouwenhoven	R. T. Greer, Lexington Building, Baltimore, Md.
Boston	Alex. Macomber	Ira M. Cushing, 39 Boylston St., Boston, Mass.
Chicago	J. E. Kearns	George H. Jones, 72 W. Adams St., Chicago, Ill.
Cincinnati	A. M. Wilson	C. G. Eichelberger, Union Gas & Elec. Co., Cincinnati, O.
Cleveland	G. B. Schneeberger	T. D. Owens, Case School of Applied Science, Cleveland, O.
Columbus	E. M. Fitz	A. W. Janowitz, 303 Hartman Building, Columbus, O.
Connecticut	E. H. Everit	A. E. Knowlton, Dunham Laboratory, Yale University, New Haven, Conn.
Denver	H. B. Dwight	R. B. Bonney, 603 Wyoming Building, Denver, Colo.
Detroit-Ann Arbor	E. L. Bailey	F. L. Snyder, 1365 Cass Ave., Detroit, Mich.
Erie	M. W. Metzner	L. H. Curtis, General Electric Co., Erie, Pa.
Fort Wayne	C. C. Grandy	L. C. Yapp, General Electric Co., Ft. Wayne, Ind.
Indianapolis-Lafayette	D. C. Pyke	C. A. Pfleiderer, Jr., Telephone Building, Indianapolis, Ind.
Ithaca	J. G. Pertsch, Jr.	Geo. F. Bason, Cornell University, Ithaca, N. Y.
Kansas City	R. L. Weber	G. E. Meredith, Kansas City Pr. & Lt. Co., Kansas City, Mo.
Lehigh Valley	H. G. Harvey	G. W. Brooks, Penna. Power & Light Co., Allentown, Pa.
Los Angeles	E. R. Stauffacher	O. F. Johnson, 740 S. Olive St., Los Angeles, Calif.
Lynn	L. E. Smith	R. B. Hussey, General Electric Co., River Works, West Lynn, Mass.
Madison	G. E. Wagner	R. G. Walter, 900 Gay Building, Madison, Wis.
Mexico	D. K. Lewis	E. F. Lopez, Fresno No. 111, Mexico, D. F., Mexico
Milwaukee	S. H. Mortensen	H. L. Smith, Louis Allis Co., 133 Stewart St., Milwaukee, Wis.
Minnesota	H. W. Meyer	N. W. Kingsley, N. W. Bell Telephone Co., Minneapolis, Minn.
New York	L. F. Morehouse	E. B. Meyer, 80 Park Place, Newark, N. J.
Oklahoma	T. M. Fariss	A. D. Stoddard, Box 382, Bartlesville, Okla.
Panama	F. B. Coyle	M. P. Benninger, Box 174, Balboa Heights, C. Z.
Philadelphia	R. B. Mateer	R. H. Silbert, Philadelphia Elec. Co., 2301 Market St., Philadelphia, Pa.
Pittsburgh	O. Needham	M. E. Skinner, Duquesne Light Co., Pittsburgh, Pa.
Pittsfield	E. D. Treanor	J. R. Rue, General Electric Co., Pittsfield, Mass.
Portland, Ore.	E. F. Pearson	H. P. Cramer, Portland Ry. Lt. & Pr. Co., Electric Bldg., Portland, Ore.
Providence	H. A. Stanley	F. N. Tompkins, Brown University, Providence, R. I.
Rochester	W. S. Burch	Elmer E. Strong, 523 Commerce Building, Rochester, N. Y.
St. Louis	J. M. Chandlee	Lee S. Washington, 717 S. 12th St., St. Louis, Mo.
San Francisco	J. A. Koontz, Jr.	A. G. Jones, 807 Rialto Building, San Francisco, Calif.
Schenectady	R. C. Muir	C. M. Cogan, Lighting Engg. Dept., General Electric Co., Schenectady, N. Y.
Seattle	C. A. Lund	J. Hellenthal, 606 Electric Bldg., Seattle, Wash.
Southern Virginia	Wm. C. Bell	Harold C. Leonard, P. O. Box 1194, Richmond, Va.
Spokane	E. R. Hannibal	James S. McNair, Washington Water Power Co., Spokane, Wash.
Springfield, Mass.	J. M. Newton	J. Frank Murray, United Elec. Lt. Co., Springfield, Mass.
Syracuse	R. D. Whitney	Walter C. Pearce, 421 S. Warren St., Syracuse, N. Y.
Toledo	Gilbert Southern	Max Neuber, 1257 Fernwood Ave., Toledo, O.
Toronto	C. E. Schwenger	D. B. Fleming, Hydro Elec. Power Commission, 190 University Ave., Toronto, Ont.
Urbana	E. B. Paine	Charles T. Knipp, University of Illinois, Urbana, Ill.
Utah	C. R. Higson	Hiram W. Clark, 400 C. & C. Bldg., Salt Lake City, Utah
Vancouver	F. W. MacNeill	A. Vilstrup, B. C. Electric Railway Co., 425 Carroll St., Vancouver, B. C.
Washington, D. C.	L. M. Evans	A. F. E. Horn, Commercial National Bank Bldg., Washington, D. C.
Worcester	L. E. Pierce	Stuart M. Anson, 1005 Park Bldg., Worcester, Mass.

Total 47

LIST OF BRANCHES

Name and Location	Chairman	Secretary
Alabama Poly. Inst., Auburn, Ala.	R. C. Dickerson	J. W. Bates
Alabama, Univ. of, University, Ala.	C. S. Carlton	W. F. Graham
Arizona, Univ. of, Tucson, Ariz.	Roy Osborne	Edward Moyle
Arkansas, Univ. of, Fayetteville, Ark.	J. A. Cunningham	C. E. Bowman
Armour Inst. of Tech., Chicago, Ill.	D. E. Richardson	J. S. Farrell
Brooklyn Poly. Inst., Brooklyn, N. Y.	H. B. Hanstein	J. E. Loerch
Bucknell Univ., Lewisburg, Pa.	E. S. Hopler	F. H. Brown
California Inst. of Tech., Pasadena	R. O. Elmore	M. L. Beeson
California, Univ. of, Berkeley, Calif.	S. W. Scarfe	F. E. Hurt
Carnegie Inst. of Tech., Pittsburgh, Pa.	W. J. Lyman	R. A. Garbett
Case School of Applied Science, Cleveland, O.	H. P. Davis	George Geyser
Cincinnati, Univ. of, Cincinnati, O.	J. F. Morrissey	C. B. Hoffmann
Clarkson Coll. of Tech., Potsdam, N. Y.	L. L. Merrill	E. T. Augustine
Clemson Agri. College, Clemson College, S. C.	R. W. Pugh	O. A. Roberts
Colorado State Agri. Coll., Ft. Collins	Frank Ayres	Lyndall Hands
Colorado, Univ. of, Boulder, Colo.	M. B. Inman	C. V. Roberts
Cooper Union, New York	E. J. Kennedy	A. W. Carlson
Denver, Univ. of, Denver, Colo.	C. G. Diller	Ray Hoover
Drexel Institute, Philadelphia, Pa.	H. Shelley	D. L. Michelson
Georgia School of Tech., Atlanta, Ga.	R. A. Goodburn	J. A. Minor
Iowa State College, Ames, Iowa	A. Paone	R. E. Paxton
Iowa, Univ. of, Iowa City, Iowa	P. A. Stover	J. M. Dean
Kansas State College, Manhattan	V. O. Clements	W. K. Lockhart
Kansas, Univ. of, Lawrence, Kans.	H. A. Hudson	R. M. Ryan
Kentucky, Univ. of, Lexington, Ky.	K. R. Smith	J. D. Taggart
Lafayette College, Easton, Pa.	Wm. Welsh	J. B. Powell
Lehigh Univ., S. Bethlehem, Pa.	E. W. Baker	D. C. Luce
Lewis Institute, Chicago, Ill.	E. Millison	C. P. Meek
Maine, Univ. of, Orono, Me.	H. L. Kelley	H. E. Bragg
Marquette Univ., Milwaukee, Wis.	E. O. Triggs	N. W. Hoffman
Massachusetts Inst. of Tech., Cambridge, Mass.	G. P. Davis	F. J. Hecht, Jr.
Michigan Agri. Coll., East Lansing	S. N. Galbraith	V. O. Bernthal
Michigan, Univ. of, Ann Arbor, Mich.	C. C. Farnum	K. W. Richards
Milwaukee, Engg. School of, Milwaukee, Wis.	I. L. Illing	A. U. Stearns
Minnesota, Univ. of, Minneapolis	L. McLeland	Fred Kapple
Missouri, Univ. of, Columbia, Mo.	M. P. Weinbach	
Montana State Coll., Bozeman, Mont.	Jack Cowan	J. A. Thaler
Nebraska, Univ. of, Lincoln, Neb.	O. J. Ferguson	O. E. Edison
Nevada, Univ. of, Reno, Nev.	Robert Plaus	G. Fowble
North Carolina State College, Raleigh, N. C.	Z. M. Harry	P. M. Sullivan
North Carolina, Univ. of, Chapel Hill	L. P. Brown	H.C.Klingenschmitt
North Dakota, Univ. of, University	S. J. Nogosek	T. E. Lee
Northeastern Univ., Boston, Mass.	L. F. Hubby	E. G. Crockett
Notre Dame, Univ. of, Notre Dame, Ind.	Frank Egan	K. Faiver
Ohio Northern Univ., Ada, Ohio	Arthur Upp	A. D. Beck
Ohio State Univ., Columbus, O.	L. S. C. Neeb	J. M. Comly
Oklahoma A. & M. Coll., Stillwater	I. T. Knight	F. C. Todd
Oklahoma, Univ. of, Norman, Okla.	R. B. Greene	M. F. Hill
Oregon Agri. Coll., Corvallis, Ore.	M. P. Bailey	E. E. Bricker
Pennsylvania State College, State College, Pa.	H. O. Alexander	Leon Lentz, Jr.
Pennsylvania, Univ. of, Philadelphia	G. V. Cresson	O. Ortlieb
Pittsburgh, Univ. of, Pittsburgh, Pa.	G. H. Campbell	F. Wills
Purdue Univ., Lafayette, Ind.	E. T. Obenchain	L. R. Bridge
Rensselaer Poly. Inst., Troy, N. Y.	F. M. Sebast	B. R. Chamberlain
Rose Poly. Inst., Terre Haute, Ind.	D. V. Eichen	R. B. Bennett
Rutgers College, New Brunswick, N. J.	E. G. Riley	E. J. Butler
Southern California, Univ. of, Los Angeles, Calif.	E. Heath	W. G. Angermann
Stanford Univ., Stanford University, Calif.	H. Bumbaugh	G. R. Stray
Swarthmore Coll., Swarthmore, Pa.	A. L. Williams	S. R. Keare
Syracuse Univ., Syracuse, N. Y.	E. J. Agnew	J. G. Hummel
Tennessee, Univ. of, Knoxville, Tenn.	E. Eubanks	W. T. Elliott
Texas A. & M. Coll., College Station	H. C. Hultgren	A. A. Ward
Texas, Univ. of, Austin, Tex.	J. P. Woods	W. K. Sonnemann
Utah, Univ., of, Salt Lake City, Utah	I. J. Kaar	M. B. McCullough
Virginia Military Inst., Lexington	J. M. Yates	J. B. Lacy, Jr.
Virginia Poly. Inst., Blacksburg, Va.	F. L. McClung	E. M. Melton
Virginia, Univ. of, University, Va.	T. S. Martin, Jr.	J. W. McNair
Washington, State Coll. of, Pullman	L. Muzzy	W. R. Davis
Washington Univ., St. Louis, Mo.	A. B. Newell	H. J. Schwenk
Washington, Univ. of, Seattle, Wash.	E. A. Kraft	E. T. Naden
West Virginia Univ., Morgantown	O. A. Brown	James Copley
Wisconsin, Univ. of, Madison, Wis.	E. J. Thomas	G. E. Bean
Yale Univ., New Haven, Conn.	W. C. Downing, Jr.	O. B. Skinner

Total 73

DIGEST OF CURRENT INDUSTRIAL NEWS

NEW CATALOGUES AND OTHER PUBLICATIONS

Mailed to interested readers by issuing companies

Blowers.—Bulletin 67, 24 pp. Describes turbine blowers used for providing forced draft for either hand fired or stokered boilers. L. J. Wing Manufacturing Company, 352 West 13th Street, New York.

Welding Electrode Holder.—Circular describes a new electrode holder for arc welding, made of aluminum with renewable copper jaws, and weighing 15 ozs. Gibb Instrument Company, Bay City, Mich.

Air Cooler.—Bulletin 1216, 16 pp. Describes the "U-Fin" air cooler for cooling the air from generator windings by the use of turbine condensate. The Griscom-Russell Company, 90 West Street, New York.

Air Heater.—Bulletin AH-1, 4 pp. Describes the CEC Air Heater for increasing furnace efficiency through the recovery of part of the heat ordinarily lost in flue gases. Combustion Engineering Corporation, Broad Street, New York.

Waterwheel Generators.—Bulletin 1127, 32 pp. Illustrates numerous hydroelectric installations, utilizing for the most part Allis-Chalmers combined generator and turbine units. It is stated that the company has installed a total capacity of more than one and one-quarter million kv-a., units ranging in size from 35 kv-a. to 65,000 kv-a. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

Solderless Connectors.—Catalog 20, 64 pp. This is the twentieth year catalog of Dossert Solderless Connectors, for stranded and solid wires, rods and tubing, and marks a very substantial enlargement over previous catalogs in the matter of data and information brought up to date. An innovation is the presentation, on a single page, of twelve of the most frequently encountered types of joints and how they can be made with Dossert connectors, illustrating the proper connector to fit the joint in question. Dossert & Company, 242 West 41st Street, New York.

NOTES OF THE INDUSTRY

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis., announce the appointment of W. C. Stevens as director of developments for all departments of the company. Mr. Stevens was general sales manager of the company since 1917. G. S. Crane has been appointed general sales manager to succeed Mr. Stevens. For the past three years Mr. Crane has been manager of controller sales at the main office in Milwaukee.

Killark Electric Manufacturing Company, St. Louis, Mo., have recently appointed George C. Knott, 67 Park Place, New York, as their New York representative. Mr. Knott was formerly of Hatheway & Knott, New York, who were the Killark agents in New York for the past ten years.

The Th. Goldschmidt Corporation, 15 William Street, New York, who are the sole importers for United States and Canada of the N & K imported radio phones, announce the appointment of Harry E. Sherwin as marketing manager of their organization.

Starting Switch.—A new single-throw starting switch, the CR-1038-A1, has been put on the market by the General Electric Company for use with small alternating-current motors. This switch is of the three-pole type, designed for quick "make and break," and is operated by an up-and-down movement of the handle. The unit is compact and of substantial construction to permit of wall or pedestal mounting.

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., announce the recent appointment of Alexander McIver as supervisor of heavy traction development, with headquarters at East Pittsburgh Works. Mr. McIver has been with the Westinghouse Company since 1909, and was previously resident engineer of the Norfolk & Western Railroad and the Chicago, Milwaukee and St. Paul Railroad electrifications.

Automatic Starter.—A new enclosed automatic starter, the CR-7056-D1, of the primary resistance type, has been developed by the General Electric Company for starting polyphase squirrel-cage induction motors under light load. The resistance of this starter is proportioned to give an inrush current of 3 ½ times the normal full load motor current, permitting the motor to develop at least 50 percent full load torque in starting.

General Electric Company, Schenectady, N. Y. Orders received by the company for the year ending December 31, 1923, amounted to $304,199,746, compared to a total of $242,739,527 for the year 1922, or a gain of twenty-five percent, according to a recent announcement by Gerard Swope, president of the company. For the fourth quarter of 1923, orders totalled $74,452,442 as compared with a total of $66,568,333 for the corresponding quarter in the year 1922, or a gain of twelve percent.

The Four Wheel Drive Auto Company, Clintonville, Wis., recently secured from the International Earth Boring Machine Company, of Chicago, the exclusive rights to manufacture and sell the earth boring machine, which has since been redesigned and is now built and sold as FWD equipment. The machine, which is mounted on a FWD truck, digs holes for poles and sets the poles in them as well. According to the manufacturer, this apparatus and three men will do more work in one day than sixty men can do by hand.

The Scott-Jaqua Company, Inc. have opened offices in the Roosevelt Building, Indianapolis, as electric sales representatives and engineers. The principals in the company are John F. Scott, former vice-president and general manager of the Varney Electric Supply Company, Indianapolis, and Charles A. Jaqua, former department manager and engineer with the Varney Company. In view of the fact that both members of the company are so well acquainted with the buying power in the electrical field in Indianapolis, they have been successful in making advantageous connections, and among the more prominent manufacturers of which they are already district representatives may be mentioned the American Steel & Wire Company, the Frank Adam Electric Company, the Kuhlman Electric Company, the Electrical Engineers Equipment Company, the T. M. Partridge Lumber Company and the Pittsburgh Reflector Company.

General Electric Company. The following personnel changes have recently been made in this company:

L. M. Nichols has been appointed assistant to the general merchandise manager, and J. O. Wetherbie has been made field supervisor of that department.

C. E. Wilson has been made managing engineer of the conduit and wire division of the Bridgeport Works.

W. H. Colman has been appointed merchandise manager of the Chicago commercial district.

Herman W. Schroeder has been appointed district auditor of the southwestern district, following the recent creation of this district by the company.

S. E. Uncapher and O. B. Rinehart have been appointed assistants to A. J. Francis, manager of fractional horsepower motor sales at the Fort Wayne plant. These appointments follow the recent resignation of S. P. Hirsch as assistant manager of this department.

Edward Dean, general superintendent for the past eighteen years of the Century Electric Company, St. Louis, was struck by a motorcycle on January 25, and died a few hours later. He was 57 years of age and a native of Michigan.